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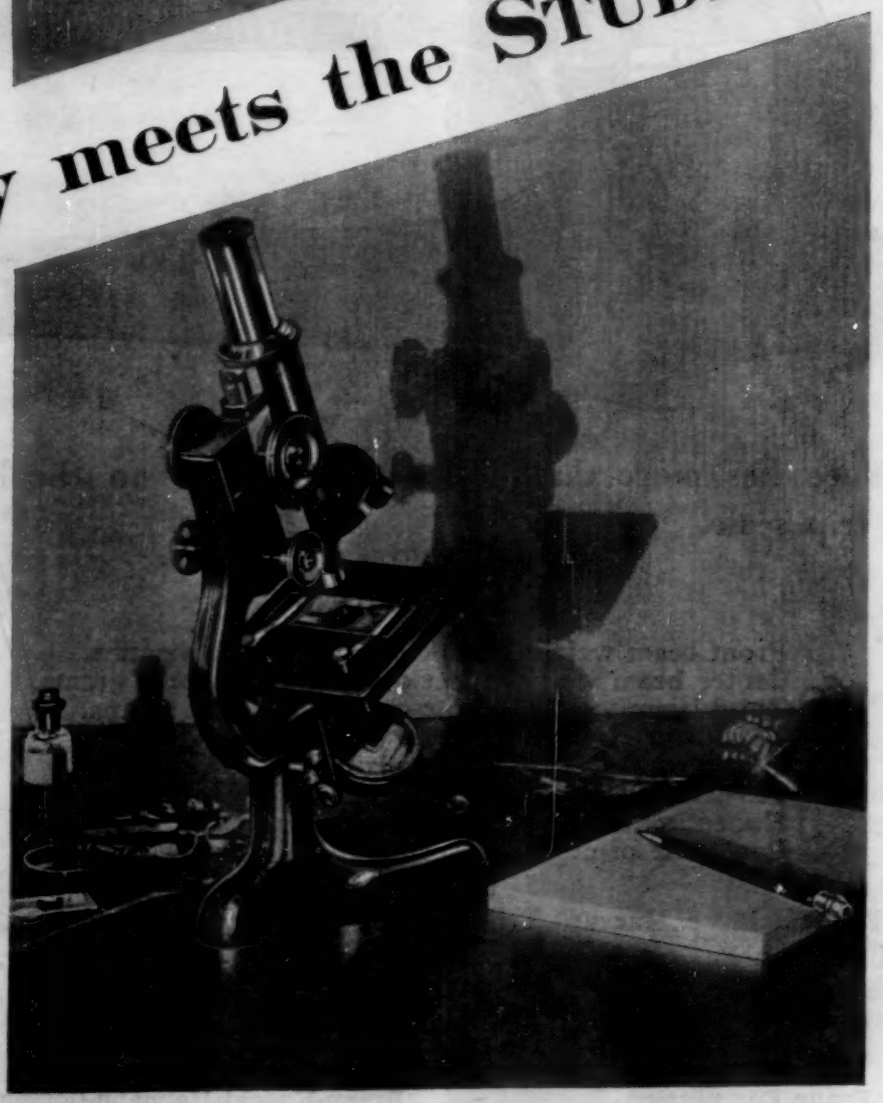

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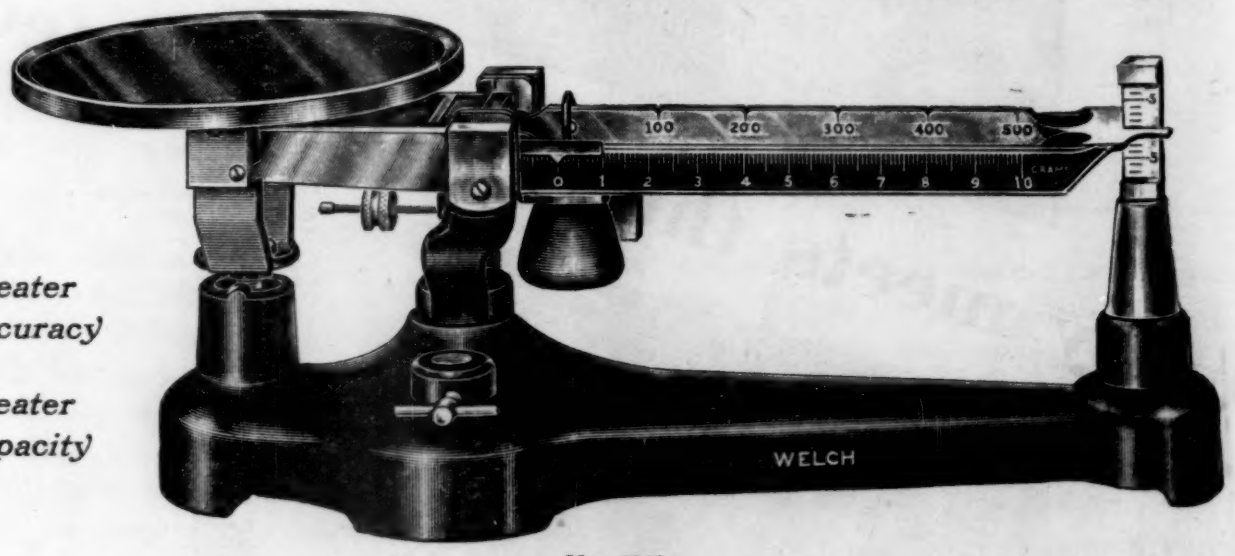

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THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

SOME ASPECTS OF RESEARCH IN THE FIELD OF ENGINEERING AND ITS FINANCIAL SUPPORT, WITH PARTICULAR REFERENCE TO CIVIL ENGINEERING AND RELATED FIELDS[1]

WHATEVER may be the objectives of Section M of the American Association for the Advancement of Science, it can be concluded with some assurance that connection with a society that is so concerned with the advancement of science makes it not inappropriate to select for the topic of the vice-presidential address, "Some Aspects of Research in the Field of Engineering and Its Financial Support." To distinguish the class of research considered from industrial research and research that is related to such matters as manufacturing, the limitation, "With Particular Reference to Civil Engineering and Related Fields," has been made.

At the beginning, the purposes and control and support of research suggest a classification into (1) research that is so directly related to financial interests of those individuals or corporations in charge and control of the work that it may well be financed by its promoters and supporters, who in turn will receive the main reward of advantage and profit, and (2) research that is more directly related in advantage and value to the public at large or to portions of it or to individuals who may at some time or other utilize the knowledge and advantages of the research but who may not have aided directly in its conduct or support.

The two classes named are, of course, not always distinct from each other, not mutually exclusive in methods and results used and obtained by one another. The privately conducted research gives by-products of scientific information and even includes investigation to discover and establish scientific principles, much of which is given to the public, to the great advantage of scientific progress. The research under public or quasi-public control contributes re-

[1] Address of the retiring vice-president of Section M—Engineering, of the American Association for the Advancement of Science, New York, N. Y., December 29, 1928.

sults that frequently are of great advantage to industry and through their utilization may bring large financial advantages to individuals. The purposes of the two classes and the distribution of the products in the main may be considered distinct and separate as related to this discussion.

AGENCIES OF RESEARCH

Industrial research and research that is supported and promoted by those who expect to profit by the products of investigation have increased by leaps and bounds in recent years, to the great advantages of the industries and also to the benefit of the public at large. In industries that may be called engineering industries this is particularly the case—electrical engineering, metallurgical engineering and many lines of manufacturing of an engineering nature have received continued contributions from research of this character. The industrial research laboratory has expanded greatly in recent years and the quality and extent of its output have been really wonderful. Fortunately, too, its future may be expected to be substantial and fertile, with profit to its supporters and with advantage to the public.

Municipal and state research laboratories have contributed to the advancement of knowledge in fields of governmental engineering activities. Research supported by our larger cities has developed and improved to a remarkable degree the methods and practice in the filtration and other purification and control of public water supplies, and likewise scientific knowledge and means and methods of treatment and handling of large volumes of sewage in such a way that sanitary conditions will prevail in its disposal have been studied and great progress has been made in the practices of disposal of wastes by the research work of municipalities and state organizations. The scientific knowledge of highway construction has been advanced greatly in the last ten years by the productive research activity of state highway departments and the U. S. Bureau of Public Roads.

In lines of more general engineering research, in fields that affect public interests and private and individual interests as well, are the research agencies of a public and semi-public character. The U. S. Bureau of Standards is an outstanding example of the investigational agency that makes it a part of its duties to carry on research activity in the field that affects the work of individuals and groups of interests in a public way with results made available to all, in small matters as well as large. Several engineering experiment stations of state universities and colleges and many of the engineering colleges less formally are doing work of the same character in various ways and along various lines. Many professors of engineering, perhaps in smaller ways and without adequate facilities, are contributing to the advancement of engineering knowledge. Private laboratories too have given many important bits of engineering science. For the second class of research activity, then, the class whose benefits accrue directly to the public and to individuals and to the interests of groups of individuals, these research agencies of the public type offer opportunities for future usefulness which should be fully utilized but which must be stimulated and supported if the needs of the public are to be met.

Another agency that has been very useful in this second class of research activity is the engineering society and its committees. Of the national engineering societies aiding and encouraging research work, the American Society of Civil Engineers for a number of years has made an effort to stimulate engineering investigations, and has to its credit a number of valuable researches in its field for which financial support as well as encouragement has been given. The investigation of steel columns and of impact in highway bridges, the researches in irrigation hydraulics and in concrete and reinforced concrete arches may be mentioned, as well as the work on stresses in railroad track, which has been carried on in collaboration with the American Railway Engineering Association and the American Railway Association. The first joint committee on concrete and reinforced concrete, originated by this society and joined by representatives of three other national organizations, gave great stimulus to experimental work in concrete and reinforced concrete and digested and rated the mass of results, utilizing the product in a report that helped to establish standard and safe practice in concrete construction, and the second joint committee has carried on its work in a similar way.

The American Society for Testing Materials has been prolific in stimulating and reporting researches in its field, giving the results freely to the public and safeguarding their publication with the effort to maintain an independent, unbiased point of view. The engineering science so produced and reported has proved of great value to the engineering public, and a large part of it has been very advantageous to building and structural work. Another society, the American Concrete Institute, has been giving more and more assistance in the stimulation and reporting of scientific information on the properties, action and utilization of products made up with cement and other materials. These three societies are mentioned as representing the kind of agencies that may be expected to be helpful in the conduct of research in the future.

Two methods of procedure have been used in the work of the societies referred to and their research

committees: (a) conduct of investigation by the committee itself or under the direction of a member of the committee, with the society furnishing the funds for its support or obtaining part of it from other sources; (b) the committee functioning by outlining, stimulating and arranging for investigational work and finally collecting, interpreting and reporting the results and applying them to the problem and formulating principles that may have been established. Both these methods have been found useful and their continuation may well be accepted.

Distinction between Classes of Research Activity

Perhaps it may be well to distinguish between the two classes of research activity that have been named: (a) that privately conducted and having the product privately controlled, and (b) that more publicly conducted and having the product freely usable by all.

First, let it be understood that nothing derogatory to the first class is intended. Its propriety and its value are appreciated, and the further development of its activity is assured. This is written rather to stress the need of the development and extension of the second class and to make a plea for its encouragement and its larger financial support in order to insure to the public the full advantages of this class of research.

The first class, then, has for its objective purposes of financial gain, its results to be private and confidential and its use restrained by patents or other forms of ownership. In the engineering field, this class of research is useful, for example, in industrial processes and in details of manufacturing. Its main purpose may be called selfish and perhaps will be actuated by the commercial instinct, though, of course, the utilization of the results may benefit the public and the by-products may be given freely to the scientific world.

The second class of research activity has a more direct connection with the general public and with individuals not connected with the research agency. For one thing, many of the results may be useful in a professional way. To illustrate, the engineer or the architect may utilize the principles, the methods, the scientific findings, to serve a client, who may be an individual, a corporation, a municipality. Naturally the client can not by himself spend the money and the time in an investigation to develop the knowledge needed in the design and construction. The engineer does not profit from the use of the information in a way that will warrant his maintaining the research activity, even though the new knowledge may give added prestige to his profession. This professional aspect of research is of the highest importance to the engineer, for the practice of engineering at the present day is based upon engineering science and this engineering science must be fed by research or the art of engineering will become stagnant.

Another aspect of the question is the need for independent, unselfish, unbiased attack and treatment of many research problems that otherwise would not be studied and for the fuller and more general investigation of them with a view to advancing engineering science and establishing principles in the engineering line that will be of service to mankind in this field. Then, too, many people have some mistrust of information that comes from commercial sources, even though the research has been ably conducted. A main reason for the support of this second class of research activity is that it will provide an attack and study of problems otherwise overlooked or neglected, that the results may be accepted as unbiased and the conclusions as independently and judicially determined, and that the knowledge will be disseminated and be freely usable by the public.

Financial Support of Research

Some comments on the financial side of research activities may be apropos. Research costs money. There must be adequate funds to support it. Its cost is increasing and the research problems to be attacked are becoming larger, more complicated and more expensive in their nature. Reference is not made here to the smaller, unpretentious matters but to the larger projects, requiring more elaborate treatment, many of them on large-scale structures or life-size samples and conditions. The conduct of research on important projects involves the expenditure of large sums of money. In reviewing the situation in the field of engineering, the committee on research of one of the national engineering societies expressed itself as being struck with the great opportunities for research work in a variety of research projects in its field, research that would undoubtedly be productive of valuable results and would bring returns many times the cost, and the committee further said that scientific information on these projects was urgently needed, but it came to the conclusion that funds could not readily be found at the present time to finance such work in an adequate manner.

The type of engineering research here referred to requires expert direction and expert workmanship. It is not the place for the amateur. Successful conduct of the large and complicated investigation implies skilled insight, trained aids, experienced workers and organized activity. Not only is the laborer worthy of his hire, but the expenditure of funds and time and the very life of the investigation itself make it essential that in these projects the research staff

shall be of the highest skill and ability. All of this goes to show that without adequate financial support the work will languish, falter and fail.

What are the sources of funds, for investigations of this type? The engineering college may have some small funds available for minor matters of experimentation. The engineering experiment stations of state universities have conducted important research projects with funds received from state appropriations, and the products of these investigations are very creditable to the stations. State highway departments and the U. S. Bureau of Public Roads have, of course, utilized very effectively available funds under their control in conducting important research work, with results that have great value. The Bureau of Standards, covering as it does a wide field, has made many important research contributions on a great variety of subjects. But valuable as is the output derived from financial support obtained in these ways, there are other sources of funds now utilized in research work of this character that are productive of valuable results.

The additional sources of financial support given research organizations should have recognition in this discussion. Their nature and scope may best be realized by the mention of a few examples. The important investigation of the fatigue of metals at the University of Illinois was financed largely by funds contributed by the Engineering Foundation and by manufacturers interested in the phenomena of fatigue of metals. The Portland Cement Association has for some years been providing funds for carrying on at and by the Bureau of Standards an elaborate and thorough research on the nature and properties of Portland cement as affected by raw materials and methods of manufacture, the study costing in the end probably several hundred thousand dollars—and this in addition to the outstanding work on concrete which has been conducted in the laboratory of the association, whose results have been given fully to the public. The research on stresses in railroad track under the joint sponsorship of the American Society of Civil Engineers and the American Railway Engineering Association, was started in 1914 with financial support from the two societies and in the later years has been supported by contributions from steel rail manufacturers and from funds granted by the American Railway Association. The structural steel column research, carried on at the University of Wisconsin, has been supported from funds provided by the Engineering Foundation and from contributions from bridge manufacturers. The test of the Stevenson Creek arch dam in California was made possible by large funds given by the Engineering Foundation and by contributions from power companies and industrial interests in the west, and the research was made effective and scientifically successful through the cooperation of the Bureau of Standards in sending an able and experienced tester of concrete structures (W. A. Slater) to conduct the testing work. In recent years the engineering experiment stations and other college research organizations have added to the amount and value of their research output by various cooperative arrangements with the industries and with engineering societies which have given financial support to projects that have the same general public character as those named above.

It will be evident to all that there is a limit to the funds that research organizations can contribute to general investigational work from their own resources, and that institutions like engineering societies have their own limitations in the financial support of research, though beyond their money contributions they may be of great service in encouraging the progress of research. The cooperative arrangements just referred to whereby supporting funds are contributed have proved satisfactory to all sides, and the method is well worthy of large expansion as a source of support in the future. The other methods of support already mentioned are also satisfactory and it is hoped will prove even more fruitful in the future. Since so much is needed, effort should be made to secure funds from every proper source.

Mention has been made of help received in large research projects from the Engineering Foundation. It may be appropriate here to add a further word about this stimulator and supporter of engineering research. The Engineering Foundation was formed as an adjunct of the four national engineering societies (usually called the four Founder Societies) to stimulate engineering research, to receive contributions and endowments, to aid research projects and even to conduct research. The foundation's endowment fund was founded by princely gifts by Ambrose Swasey, and others have added to the endowment. During its existence, the Engineering Foundation has financed many important engineering researches. It also serves as an agency for securing funds that may be expended currently for a special investigation. It is hoped that its endowment fund may be augmented many times in the near future by gifts like those of Mr. Swasey, for no enterprise offers higher results or greater advances to the engineering world and to its public than one that promotes the advancement of engineering knowledge as does a foundation like the Engineering Foundation. May this great agency be blessed with gifts of princely size adequate for the high service it can render.

It is well to note some characteristics of cooperative arrangements as safeguarding the value of the research to the public and upholding the independence and disinterestedness of the investigation and its findings, as required by some of the cooperating institutions. An advisory consulting committee considers the problem and the method of investigation, and may advise in the interpretation of results. The laboratory directs the investigation and controls the work and finally interprets the results and prepares the report. The results of the investigation are the property of the laboratory, and the institution will make publication if the value warrants. The product of the research is intended to be fully available to the public except that a patent may be applied for if this step is thought necessary to protect the interests of the public. It is seen that the purpose of the provisions is to conduct the research as a public activity, and that the advantages accruing to those who have financially supported it may be shared by others.

At another time I have said that pioneer American engineering depended almost wholly on ingenuity, experience, precedent, vision and judgment, and engineering science played a minor rôle. The increasing magnitude and difficulties of engineering projects, the need for greater permanency, economy and safety, and the greatly diversified nature of engineering work have emphasized the importance of basing engineering art more fully on engineering science. It will not be overlooked by any one that engineering will continue to need ingenuity, experience and judgment, and rules, precedent and vision, but more and more, as time goes on, will it be dependent on science and that accumulation of applied science that may be grouped under the term, "engineering science." And engineering science must be fed upon research, and thus research is essential to its advancement, to its fuller growth.

No attempt has been made here to name problems or projects that need the light of research thrown on them. The belief may be expressed, however, that the members of Section M recognize the great value and need of research in engineering lines and appreciate the importance of adequate provision of funds for the purpose. It is the hope of the retiring vice-president that Section M in some way may give effective aid in bringing this need to the attention of those who may be able and willing to contribute liberally to the support of engineering research.

ARTHUR N. TALBOT

UNIVERSITY OF ILLINOIS

CELLULAR DIVISION IN RELATION TO CANCER[1]

CANCER is a disease characterized by division and multiplication of cells. In the unrestrained condition the tendency of cells is to grow and multiply. In tissue or cell culture each cell divides twice and the colony doubles in volume. A colony, originally one cubic millimeter, will form approximately one cubic centimeter in twenty days. After sixty days the volume of tissue would be more than one cubic meter, and in less than one hundred days, one million cubic meters. Indeed, Carrel has estimated that, if the tissue cultures which he has kept growing for sixteen years had not been restrained, the mass would be not only larger than the planet, but even greater than the universe.

Cells are endowed with far greater potentialities than they display within the human body. There the immense capacity for growth possessed by the cells of the human tissue must be kept under restraint while these cells live as part of the organism within the body. The resting condition of adult tissue depends upon the composition of the fluids or humors in which they are immersed, or, to put it in other words, the environment of the cell determines the rate of its growth and division.

In the light of this, cancer is characterized by more or less suppression of normal balanced cell activities with accentuation of that of cellular multiplication. Suppression of multiplication is removed and there is a release from normal growth gradients which determine body structure. Inhibition is replaced by the embryonic qualities of multiplication.

In cancer we have to do with a state, not a thing—with a state of cell wherein the cell is allowed to grow and multiply without the usual restraint common to adult body tissue. A most important study, therefore, is the mechanism whereby restraint of cell growth may be obtained.

In the consideration of cell division we have to take thought of the mechanism and organization of the cell. It is well in this regard to have a model for thought in order to consider the changes which take place, exactly as the physicists have their model of the atom and the chemists have their model of the molecule. The simplest structure capable of sustaining life is the unit with which we have to do, as the physicists have to do with the atom and the chemists with the molecule.

[1] An address before the Wilmington section of the American Chemical Society, illustrated by moving pictures of cell division. October 17, 1928.

As in these two last units, the structure or organization is of importance, as the unit becomes more and more complicated, the structure becomes of greater importance. For purposes of thought, the cell may be divided into four portions: (1) the nucleus, which is alkaline (about pH 7.50); (2) the protoplasm, which is acid (about pH 6.6–6.8); (3) the semipermeable cell membrane, and (4) the environment or liquid in which it is bathed (and this in the human body consists of the blood plasma and tissue juices with a normal pH of 7.36–7.38). The cell and its environment must be considered as one.

In this arrangement, no immediate consideration is taken of the chemical substances composing the cell, and these are complicated in the extreme. The proteins of life are the most chemically specific substances known. Their variation is very wide and Abderhalden has estimated from the possibility of combination of the various amino-acids that there is a possibility of 24^{20} different combinations to form different proteins, so that the chemical combinations and chemical minuteness of the substances composing vital cells are so enormous and delicate that they stagger the scientific imagination and seem in the light of our limited knowledge to present an overpowering obstacle to the study of cell processes and function.

However, it is fortunate that nature at some stage in her complexity rejuvenates her simplicity. The cell reacts as a unit and there are certain phenomena which are common to all cells. There are regularities in the complexity of cell phenomena which make it possible to study cell processes from a physicochemical standpoint and temporarily to neglect the abstruseness of intimate chemical composition which seemed to present an insuperable obstacle.

In this renewal of simplicity, the cell may be regarded as a negatively charged particle, existing in an alkaline aqueous medium. As all life is colloid, we have, therefore, to do with a heterogeneous system of the negatively charged type and more of the nature of a suspensoid, in that alterations in the charge affect the stability of the system. Life is, therefore, the continuance of colloidal changes in an aqueous medium, and the cell is the unit of life.

There is such uniformity in nature and the reaction is so constant to constant stimuli that there must be an *equilibrium* or balance controlling the processes of life in its normality, and in its deviations in disease and age. This balance is dependent at least in some degree upon charge, as the proteins are amphoteric substances and depend for their charge upon inorganic salts and other electrolytes.

In the nucleus we have as yet little opportunity for the study of alterations in charge, but it is known that in cell division the nucleus obeys the laws of the swelling of colloids. In cell division the first noticeable changes which are produced in the cells are those of alteration in the chromosomes. These little substances are each made up of discrete particles called genes, and there are thousands of genes in each chromosome. The walls of the nucleus dissolve just before division is to take place and the tiny rods of the chromosomes form a spindle-shaped figure and into the middle of the spindle the chromosomes are drawn. They arrange themselves in an equatorial belt in two divisions and then ensues an equatorial "tug of war" until they divide, as you will see in the moving pictures, into two parts. They split lengthwise and with this division a constriction appears on the surface of the cell which spreads and gradually encircles it. This constriction cuts into the cell and it divides into two cells. After a pause of an hour or so another division takes place, and this appears at right angles to the first.

These are the processes in the nucleus which are visible in the moving pictures, but the influences outside the cell can not be thus shown. Division in the cell, as has been shown by Carrel and others, is dependent upon environmental influences. In our consideration of the colloid cell as a unit, the variations in the semipermeable membranes or surface films underlie the response of irritable tissues to stimulation. The primary reactions in stimulation to cell division are surface reactions, as is shown by their sensitivity to surface-active compounds and to changes in electrical polarization.

If a marine cell is placed in balanced sea-water, division takes place at a measurable rate. If this sea-water environment is altered by the addition of 1–1000 of sodium chloride, or if the pH of the solution is made slightly more alkaline, cell division takes place at a greater rate. If, on the contrary, 1–1000 of calcium is added or the pH made relatively more acid, division is greatly reduced or stops. Thus cell division has here been altered by changing environmental influences outside cell membrane, and nuclear division within the cell membrane has been influenced by this means. There is also alteration in cell permeability and electrical conductivity. All this shows the possibility of influencing cell division by environmental changes without destruction of the cell itself.

As cancer is a disease of cell division, the study of the environment of the cell in the human body, as shown in the blood plasma, offers considerable interest. If these changes in the environment could be shown to be pertinent in the cell division of cancer, it might open up new avenues of research and new possibilities of control of cell division in cancer.

In this disease, it is too much to hope to find a means of destroying the cancer cell alone, without the destruction of surrounding or accompanying normal cells. The so-called cancer cell offers too little difference from normal cells to expect that there should be a chemical specificity in the cancer cell which distinguishes it to such a degree from normal cells as to make it possible to attack the cancer cell alone. But it is not too much to hope that cancer cells can be restrained from division and, if this is done, the cancer cell will lose the quality which characterizes it—its power of spreading in the tissue which depends upon multiplication by division. The form of the cell is a function of time and if division can be slowed the cancer cell loses its characteristics. Like weeds in a field, if the cells can be made to cease to grow and multiply, they will not spread, even if they are not destroyed.

In this study of the environment, or blood plasma, Reding, of the Cancer Center at Brussels, has found that cancer is generally associated with a more alkaline pH[2] and with a diminution in the ionized calcium and even total calcium in the blood plasma. In other words, in cancer, a disease which is dependent upon cell multiplication, are found conditions which favor such multiplication in single-celled marine organisms. In addition, after X-rays or radium treatment, which is one of the most effective means of treatment, Reding finds there is a shift in pH (when the treatment is clinically effective) towards the relatively acid side of normal and the ionized calcium is increased in amount. In other words, the treatment which is effective in controlling cancer produces conditions similar to those in which cell division is hindered in single-celled organisms.

To the cancer research worker, these findings, if confirmed by others, will be most illuminating. They will show that it is possible to control cell division in the body by environmental changes and open up new fields in the attempt to control such cell division by the aid of chemical substances and by the alteration of equilibrium. Any cell with a definite physico-chemical organization will follow a constant course of transformation if external conditions are constant, but, if these are changed, the course of transformation will also be altered. These findings, too, will give a means of biological control of the present most effective treatment of inoperable cancer, the radiation from X-rays and radium, where there are now only the rough criteria of the clinical aspects of the tumor.

And last, but by no means least important, is the finding that the physical forces of radiation by X-rays and radium produce measurable chemical changes in the blood plasma, or the physico-chemical environment of the vital system. This fact is most intriguing in that it leads to the hope that by chemical alterations in the blood it may be possible to produce effects similar to radiation, or to extend the effects of radiation by chemical means. In the moving pictures to-night you will see the effect of radiation upon cells and cell division and the sudden cessation of activity as a result of radiation. The mechanism of these effects has been thought to be upon the nucleus and chromosomes, as has been shown by Muller in his mutation experiments, but there seems to be another effect which influences the environment, and it may be that this is an effect upon the cell membrane. It may be that by altering the environment of the cell, the blood plasma, that such membrane effects may be obtained as an aid or substitution to radiation in preventing cell division.

So you see that in these problems the chemists are our hope, but it is our duty to state the problem of cancer to them in such terms as to explain the mechanism of action of the cells and in this way get the full value of their advice. The unit of life is the cell and the cell is colloid in character. Substances which may have a hope of benefiting the disease will be those which restrain cell division without complete destruction of cell function and those which will permit the cell to mature from its embryonic condition to that state where the inhibitions or restraint of the growth gradients are once more effective. Cancer is a disease of age and this is a time when cell division should be limited.

If this restraint of division can be obtained or if the influence of radiation can be extended, the hope of benefit in this disease shines brightly. In this we are gratefully in the hands of our friends, the chemists, and it is to them that we wish to state our problem in its mechanism, so that there may be an intelligent viewpoint for them to apply the knowledge which is theirs.

ELLICE MCDONALD
PHILADELPHIA, PA.

[2] The work of Reding and some studies by ourselves will be published in book form under the title, "Blood Studies in Cancer," Williams and Wilkins Company, Baltimore. There will also be included a description of a new electrical pH measure and some description of the method of its use with the quinhydrone electrode. The importance of pH in the study of cancer has led the Cancer Research Committee of the Graduate School of Medicine of the University of Pennsylvania to work on the improvement and exactitude of pH measurements.

JOHN MERLE COULTER

IN the recent death of John Merle Coulter, professor emeritus of botany, of the University of Chicago, plant science has lost a profound student, an inspiring

teacher and a prominent leader. Professor Coulter was born of missionary parents at Ningpo, China, on November 20, 1851, and died at Yonkers, New York, on December 23, 1928. His father died in China in 1853, and his mother with her two sons, John and Stanley, returned to America a few months later to the home of her father, Dr. John F. Crowe, of Hanover, Indiana. Professor Coulter's boyhood was spent largely in Hanover, his early education being cared for in nearby private schools. Entering Hanover College, he was graduated with his A.B. degree in 1870 and from the same institution received his A.M. degree in 1873. From Indiana University he received the Ph.D. degree in 1882 and the LL.D. in 1920.

In 1870 he went to Logansport, Indiana, and taught Latin in the Presbyterian Academy there. He was professor of natural sciences at Hanover College from 1874 to 1879; professor of biology, Wabash College, Crawfordsville, Indiana, 1879 to 1891; president and professor of botany in Indiana University, Bloomington, Indiana, 1891 to 1893; president of Lake Forest University, Lake Forest, Illinois, 1893 to 1896; professor and head of the department of botany in the University of Chicago, 1896 to 1925, and scientific adviser to the Boyce Thompson Institute for Plant Research, Yonkers, New York, 1925 to 1928. He was largely responsible for the foundation of the Boyce Thompson Institute for Plant Research, and was a member of its board of directors from its foundation until the time of his death.

At the request of the board of trustees he retained his position as head of the department of botany at the University of Chicago for three years after he reached the retiring age of seventy.

At the age of seventy-two he was granted, by the board of trustees, a leave of absence to visit and lecture in China and Japan. This journey, on which he was accompanied by Mrs. Coulter, was arranged by a government organization known as the National Association for the Advancement of Education. On this journey he visited all the principal universities and colleges in both countries, and delivered more than two hundred lectures and addresses besides attending numerous receptions and banquets. The object of the visit was to promote friendly and understanding relations between the educational institutions of America and those of the Orient.

Although he early showed an interest in geology and natural history, his botanical work really began in 1872 when he became a junior member of the Hayden Survey of the Territories. Joining the party as assistant geologist, he was soon appointed the official botanist of the expedition on account of his interests shown in collecting plants during the stay of the party at their western base of supplies. He was therefore a member of the first group of scientists to visit what is now Yellowstone Park, to begin the study of its geysers and to collect specimens of its flora. While studying these collections at Washington, preparatory to writing the report of the botanist of the Hayden expedition, he came in contact with Asa Gray, and this acquaintance ripened into a lifelong friendship. Coulter soon became Gray's most brilliant pupil. This close contact with Gray eventually culminated in the production of the sixth edition of Gray's "Manual of Botany," revised by Coulter and Watson.

Following in the footsteps of his great teacher, Coulter issued in 1885 his "Manual of the Botany of the Rocky Mountain Region," that became when revised by Nelson in 1909 the "New Manual of Botany of the Central Rocky Mountains." In 1892–93 this was followed by the "Manual of Texan Botany."

In close sympathy with the teaching of plant science in secondary schools, Professor Coulter wrote in the following years a series of elementary text-books which included "Plant Relations" in 1901, "Plant Structures" in 1904, "Plant Studies" in 1904, "A Text-book of Botany" in 1906, "Fundamentals of Plant Breeding" in 1914, "The Evolution of Sex in Plants" in 1914, "Evolution, Heredity and Eugenics" in 1916 and "Plant Genetics" in 1918.

Professor Coulter founded the *Botanical Gazette* in 1875, and for fifty years was its editor. This journal, which he not only edited but in its early days managed and financed, soon became the leading botanical publication in America, and has long been recognized in every country as one of the best organs for the publication of the results of botanical investigation. In it there early appeared a series of articles on the Umbelliferae by Coulter and Rose that finally took the form of a "Monograph of North American Umbelliferae" by John M. Coulter and J. N. Rose, appearing as Contribution U. S. Herbarium 7 (256 pp., 65 figs., 1900). Soon afterwards the appearance of "Preliminary Revision of North American Species of Cactus, Anhalonium and Lophophora" and "Preliminary Revision of North American Species of Echinocactus, Cereus and Opuntia," Contribution U. S. Nat. Herb. 3 (91–132, 355–462, 1894, 1896), by Coulter himself seems to indicate that his primary interests still lay in taxonomy.

The acceptance of the position as head of the department of botany in the newly organized University of Chicago, in 1896, seemed to mark the beginning of a period in his life dominated by a major interest in plant morphology. Soon a series of "Contributions from the Hull Botanical Laboratory," largely morpho-

logical and the results of the researches of Coulter and his students, began to appear in the *Botanical Gazette*. This series reached its 388th number in the December, 1928, issue of the *Gazette*. The advances in plant morphology to which this series contributed so largely were summarized in two of Coulter's most important books, written in collaboration with one of his most distinguished pupils, C. J. Chamberlain, now as then a professor in the department of botany at Chicago. These are "Morphology of Angiosperms" (348 pp., 113 figs., New York, 1903) and "Morphology of Gymnosperms" (458 pp., 462 figs., Chicago, 1910). These were followed by a "Text-book of Botany" (for colleges) to which Coulter contributed the section on morphology.

As a teacher Professor Coulter excelled. His clearness of presentation, his wide perspective, his keen sense of proportion, his remarkable powers of generalization and his kindly, fatherly interest in all his students made him an ideal guide for young scientists. No other botanist in America attracted so many students to his classes and no one was more successful in inspiring each student to excel in the field of his particular interest. His great versatility is seen in the fact that although he was originally a taxonomist and later a morphologist, his students excelled not only in those fields but also in plant physiology, plant ecology, paleobotany and phytopathology. More than 175 students were graduated with the doctor's degree from the department over which he presided for more than a quarter of a century. Many of these have won the highest botanical positions in the United States, Canada, China, Japan, India, Australia and Great Britain. Perhaps his most unique achievement in this respect was to build up a large department at the University of Chicago, a department in which the principal branches of plant science were represented by specialists, entirely from the personnel of his own students.

Professor Coulter was a profoundly religious man. For twenty-nine years he taught a large men's class in the Sunday School of the Hyde Park Presbyterian Church and occasionally occupied the pulpit of the same church. His was also an influential voice in the councils of the local church and in those of the larger organization of which it was a part. He could see no conflict between the truths of religion and those of science. When the teachings of theology conflicted with those of science he revised his theology but kept his religion.

Some of his religious views have been expressed in such articles as: "The Religion of a Scientist,"[1] "What Biology has Contributed to Religion,"[2] "Jesus' Attitude towards a New Religious Movement,"[3] "The Attitude of Jesus Towards Religion,"[4] and "Where Evolution and Religion Meet" (in collaboration with his son, Merle C. Coulter) (105 pp., 1924).

He was an attractive and inspiring speaker and was much in demand for commencement and convocation addresses. Twice he was convocation orator at the University of Chicago.

His membership in scientific societies seems to have begun with that in the Indiana Academy of Science, of which he was president in 1886. A fellow of the American Association for the Advancement of Science, he was elected its president in 1918. For years a member of the Botanical Society of America, he was its president in 1897 and again in 1915. He presided over the American Association of University Professors in 1918, over the Illinois State Academy of Science in 1910 and over the Chicago Academy of Science from 1916 to 1924. He was a member of the National Academy of Sciences, the American Society of Naturalists, the Washington Academy of Science and of many foreign botanical organizations.

In 1874 Professor Coulter married Georgia M. Gaylord, of Delphi, Indiana, who survives him. Six children were the result of this marriage. A son and a daughter died in childhood, while two sons and two daughters are still living. They are John Gaylord, of Paris, France; Grace A., of Chicago, Illinois; Margaret (Mrs. Edward R. Yarnell), of Easton, Pennsylvania, and Merle Crowe, of Chicago, Illinois. Both daughters were graduated from the University of Chicago and both sons received the Ph.D. degree from the department presided over by their father. Merle C. is now associate professor of plant genetics in the same department.

At the celebration of the quarter-centennial of the University of Chicago, in June, 1916, the doctors in botany, then numbering eighty, gave Professor Coulter a presentation volume containing a record of all doctors graduated from the department up to that time.

On December 27, 1928, there was founded a John M. Coulter Research Fellowship at the University of Chicago by presenting the university with pledges amounting to more than $25,000. This sum had been subscribed by 130 doctors and 75 alumni and past students of the department of botany. This fellowship, for which only the interest of the fund will be used, is to carry forward the work in which Professor Coulter was so vitally interested. It will be tenable at the University of Chicago in any branch of plant science and will be granted to candidates for the doctor's degree who have research well under way. Such fellows will devote at least one half of their time

[1] *Biblical World*, 41: 80–85, 1913.
[2] *Ibid.*, 41: 219–223, 1913.
[3] *Homiletic Rev.*, 67: 175–177, 1914.
[4] *Ibid.*, 70: 183–185, 1915.

to research, will be exempt from tuition fees and will have no service or teaching duties. It seems fitting that the first nomination to the Coulter Fellowship is to be made within a very few months of the death of the great teacher whose memory it perpetuates.

Another movement to honor Professor Coulter culminated on the evening of December 28, 1928, when the president of the Botanical Society of America, Professor A. H. R. Buller, presented to Mrs. Coulter a memorial volume containing the names and the appreciative letters of hundreds of Professor Coulter's botanical friends. The volume was accompanied by a silver tea service. The gifts were received by Dr. Wm. Crocker, acting on behalf of Mrs. Coulter.

While all regret that Professor Coulter did not live to see the culmination of these efforts to do him honor, it is some satisfaction to remember that he was aware of the completion of the John M. Coulter Research Fellowship Fund and of the compilation of the memorial volume by the members of the Botanical Society, and that he expressed his high appreciation of these tokens of affection coming from his pupils and his friends.

GEO. D. FULLER

THE UNIVERSITY OF CHICAGO

SCIENTIFIC EVENTS

BIOLOGICAL ABSTRACTS

THE following is a somewhat abbreviated statement of the points brought out in a report on the progress of *Biological Abstracts* presented to the council of the American Association at the fifth New York meeting, by Professor Herbert Osborn, representative of the association on the board of trustees of *Biological Abstracts*. The journal has been promoted by the Union of American Biological Societies and has received support from the Rockefeller Foundation, which has contributed $50,000 per annum to be available during a period of seven years. In addition, the project receives subscriptions from institutions and individuals, reported to have aggregated $41,860.37 for the period from July 1, 1926, to April 20, 1928. Ten issues have been published, Volume I being complete, except for the index, and Volume II started. The scope and complexity of this project are indicated by the following quotations from a statement recently made by the editor-in-chief, Dr. J. R. Schramm.

1. The literature is extremely widely scattered and consequently more difficult and costly to assemble than that of other fields, as evidenced by the fact that some 6,000 serials must be perused to make the journal fairly complete. (*Chemical Abstracts* at present abstracts from 1,250 periodicals.)

2. No other science begins to present the complex indexing problem presented by biology, largely because of the enormous extent of taxonomic literature. It now requires six persons, part scientifically trained and part clerical, to do the indexing of systematic botany and zoology alone, and this staff may require additional slight increase. It is generally conceded, however, that the indexing procedure in *Biological Abstracts* is limited to the necessary.

3. The subject is more diversified than that of any of the other major scientific fields, biology being to a larger degree the meeting ground of all the natural sciences. The central staff must necessarily be larger and more diversified in its training.

The editor-in-chief has made the following statements concerning the progress already made, in the light of the original plans and estimations. It was estimated that the literature to be abstracted would total about 40,000 titles annually and there is as yet no reason for modifying this estimate, though probably the number will eventually be larger. It was estimated that abstracts would be printed at the rate of twelve per page, of the format and typography finally adopted, and the average for Volume I is 113. The cost of printing the text was somewhat overestimated, but no statement can yet be made concerning the indexes. It was estimated that the editorial work would cost $75,000 annually and it appears that that amount may suffice for the next few years.

It is too early to predict the degree of completeness that may be achieved in this valuable service to biologists, but a very excellent beginning has been made and the enterprise surely deserves the hearty support of the association and of all members interested in biological work.

BURTON E. LIVINGSTON,
Permanent Secretary

MECHANICAL STANDARDS ADVISORY COUNCIL

SIXTY organizations having an interest in standardization in the mechanical engineering field were invited to join the Mechanical Standards Advisory Council. A large percentage of them accepted and sent official delegates to represent them at the permanent organization meeting which was held on Monday, December 3, in the Engineering Societies Building, New York.

What to standardize, when to standardize and how to standardize, to the general economic advantage and without embarrassment to the financially concerned interests in the mechanical field, are the basic questions which the mechanical industries undertook to solve.

The functions of the council, as outlined in the constitution adopted at the meeting, are as follows:

1. To endeavor to obtain, at the request of any interested group, the desired cooperation of organizations in any standardization project in the mechanical field.
2. To confer with any organization in the mechanical field interested in or carrying on work which eventually may be presented for action under the rules of procedure of the American Standards Association.
3. To advise the American Standards Association on questions of policy relating to standardization applying to products of the mechanical industries.
4. To serve as a general coordinating medium in the mechanical field, within the scope of the constitution, by-laws and rules of procedure of the American Standards Association.
5. To consider—
   (a) the desirability and practicability of standardization projects within its field,
   (b) the order in which standards shall be developed,
   (c) the scope of projects,
   (d) sponsorships for the necessary sectional committees, and
   (e) the adjustment of conflicts and the clearing up of ambiguities.
6. To follow up and expedite work in the development of standards.

In accordance with its constitution, the council voted to designate the representatives of the Society of Automotive Engineers, the National Machine Tool Builders Association, the American Standards Association, the Manufacturers Standardization Society of the Valve and Fittings Industry, the American Society for Testing Materials and the American Society of Mechanical Engineers as the executive committee of the new council.

The meeting recently held followed two preceding conferences of April 7, 1926, and June 20, 1928. The first conference, called by the society, answered the questions of "how to standardize" by unanimously determining that the procedure of the American Standards Association (formerly known as the American Engineering Standards Committee) is the method which should be employed in developing and promulgating a standard of sufficient scope to seriously affect more than a single group of interests.

The second conference decided upon "what and when to standardize" by approving the recommendations of the first conference's special plan and scope committee that such functions should rest with industry itself and by creating a temporary executive committee with power to further develop a basic instrument or constitution for the necessary organization, to be known as the Mechanical Standards Advisory Council, and also to call a meeting at which this council would be organized upon a permanent basis.

THE SOUTHERN CALIFORNIA RIFT CLUB

THE Rift Club meets several times a year at localities where faults are shown, for study and discussion. For the winter meeting the adjacent Death and Panamint Valleys of eastern California were selected, and a detailed road and camping schedule covering four days from December 27 to 30 was prepared. Over fifty people made the trip, in a caravan of twenty-one motor cars, under the leadership of Mr. R. B. Peters, of San Bernardino, club president, and Professor J. E. Wolff, of Harvard University (retired), arranger of the program.

Death and Panamint Valleys are narrow troughs extending north and south between lofty mountain ranges. Each range is a tilted fault block, with a steep compound fault escarpment as its western boundary. The party studied numerous component scarps of these systems, some cutting across alluvial fans. It was also noticed that the alluvial fans on the west side of each valley are broken by north-south faults, each with upthrow on the fanhead side. A noteworthy prospect was that west from Dante's View, including both Death Valley, below sea-level and the lowest point in America, and in the far distance Mt. Whitney, the highest point in the United States. These great differences of elevation are the result of geologically recent movements or faults.

Death, Panamint and adjacent valleys are more or less completely closed basins. A rather recent event in their geologic history has been the formation and subsequent desiccation of great lakes, whose shore-lines and saline deposits remain in testimony. The Rift Club noted vague shore-lines in Death Valley, clearer cases in Panamint Valley, and the perfect terrace above "Searles Lake" west of Panamint Valley.

The trip closed with a circuit of the great potash and borax works at Trona, where the brines pumped from beneath the dry floor of "Searles Lake" are fractionally crystallized to rob them of their more valuable constituents. This opportunity, and the turkey dinner which followed, the club owed to the courtesy of the American Potash and Chemical Company. The club had previously been accorded the great privileges of wood and water at every possible point, and even freedom from toll over Townsend Pass. The desert hospitality was much appreciated.

THE RIO GRANDE NATIONAL FOREST

THE Forest Service of the United States Department of Agriculture regards the Rio Grande National

Forest as a large diversified farm, the main products of which are timber and forage crops. With a net area of 1,135,764 acres, this forest contains some two billion feet of standing timber, and provides grazing annually for 200,000 head of sheep. It has 600 miles of fishing streams, 150 miles of roads and 1,200 miles of trails.

The annual crop of timber is represented by the total annual growth of all the trees in the forest. In any one year the crop is taken only from a part of the forest. Operations are confined to the cutting of ripe or mature trees, and the weeding out of those that are overmature, diseased or defective. This leaves a stand of thrifty immature trees in a condition favorable for increased growth. Timber production is thus continuous. Although the annual growth of timber now amounts to about 20,000,000 board feet, present local demand for lumber has not warranted harvesting the full annual crop, and most of the accumulation is being "stored on the stump."

Deer, elk, mountain sheep, bears, mountain lions, bobcats, blue and willow grouse, ptarmigan, ducks and many other kinds of game and wild life range on the forest. It is the policy of the Forest Service in handling the grazing of domestic livestock to reserve adequate range for the wild animals in parts of the forest which can not be used efficiently for domestic stock. Hunting is allowed under Colorado State game laws, but elk and mountain sheep are protected the year round.

Watershed protection is one of the primary considerations in the administration of the Rio Grande. The welfare of a large territory in southwestern United States and northern Mexico is dependent upon the waters of the Rio Grande, and protection from fire, overgrazing and destructive logging is necessary to maintain adequate watershed cover.

Within the forest is the Wheeler National Monument, a grotesquely eroded geological feature, set aside by presidential proclamation and named in honor of George Wheeler, United States engineer. The monument is reached by a trip of 12 miles from Creede, Colorado, over a Forest Service trail.

A descriptive booklet, "The Rio Grande National Forest, Colorado," has just been published by the Department of Agriculture, from which copies may be obtained.

REFUGES FOR MIGRATORY BIRDS

THE protection of migratory birds by the establishment of refuges in all the states and Alaska is proposed in a bill introduced by Representative Andresen, Republican, of Minnesota, and unanimously passed by the House on February 9. A similar measure, sponsored by Senator Norbeck, Republican, of South Dakota, has passed the Senate.

The house bill provides for an appropriation of $75,000 for the first year, $200,000 for the second year, $600,000 for the third year and $1,000,000 annually for the next seven years to bear the cost of land and water areas on which 125 bird refuges would be erected. The senate bill differs in that it provides an annual appropriation for an indefinite period.

The two bills will be harmonized in conference and the completed measure submitted to President Coolidge, who is said to be in sympathy with the proposed legislation. One of the purposes of the bills is to meet more effectively the obligations of the United States under the migratory bird treaty with Great Britain by lessening the dangers threatening migratory game birds from drainage and other causes.

The Andresen bill provides for the creation of a commission for the purchase and establishment of bird sanctuaries in which the states are to have representation. State approval must be had before any area is set aside within its borders for this purpose. Jurisdiction in civil and criminal cases is expressly reserved to the states, and the bill provides that in carrying out the law there shall be no interference with their game laws.

The commission will be composed of the secretary of agriculture as chairman, the secretary of commerce, the secretary of the interior, two members of the senate, to be named by the vice-president, and two members of the house, to be designated by the speaker. The governor of each state will pass on all matters arising under the law affecting his state.

AWARD OF THE LAMME MEDAL

THE Lamme Medal Committee of the American Institute of Electrical Engineers has awarded the first (1928) Lamme medal to Mr. Allan Bertram Field "for the mathematical and experimental investigation of eddy current losses in large slot-wound conductors in electrical machinery." Arrangements for the presentation of the medal will be announced later.

The Lamme medal was founded as a result of a bequest in the will of the late Benjamin G. Lamme, chief engineer of the Westinghouse Electric and Manufacturing Company, who died on July 8, 1924, to provide for the award by the institute of a gold medal (together with a bronze replica thereof) annually to a member of the American Institute of Electrical Engineers, "who has shown meritorious achievement in the development of electrical apparatus or machinery" and for the award of two such medals in some years if the accumulation from the funds warrants.

Mr. Lamme made similar bequests to the Society for the Promotion of Engineering Education and the Ohio State University, providing in the former for

the annual award of a medal "for accomplishment in technical teaching or actual advancement of the art of technical training," and in the latter for the award every five years of a medal to a graduate of the Ohio State University in any branch of engineering for meritorious achievement in engineering or the technical arts. The three organizations have adopted a common obverse for their medals and each has prepared a suitable reverse.

In order to become familiar with American practice, Mr. Field joined the General Electric Company in 1902 and spent more than a year in the testing department in Schenectady, afterwards being engaged in transformer design. He then was employed by the Bullock Electric Manufacturing Company, the Allis Chalmers Company and the Westinghouse Electric and Manufacturing Company. He was consulting engineer and professor of mechanical engineering at the University of Manchester, England, from 1914 to 1917, and during the next three years was with Vickers, Ltd., London. Since 1920 he has been consulting engineer of the Metropolitan-Vickers Electrical Company, Ltd., Manchester, England.

Mr. Field is the author of a number of important papers on electrical machinery which have appeared in the *Transactions* of the American Institute of Electrical Engineers and other engineering publications.

SCIENTIFIC NOTES AND NEWS

DR. FREDERIC A. LUCAS, director of the American Museum of Natural History from 1911 until 1923 and since honorary director, died on January 9, at the age of seventy-six years.

THOMAS A. EDISON celebrated his eighty-second birthday on February 11 at Fort Myers, Florida. There were present Mr. and Mrs. Herbert Hoover, Mr. Henry Ford, Mr. Harry S. Firestone and other friends. In the evening Mr. Edison made a speech which was broadcast from twenty-four stations.

DR. WILLIAM H. WELCH will give the principal address at the fifty-third commemoration day exercises of the Johns Hopkins University on February 22.

THE non-resident lecturer in chemistry at Cornell University under the George Fisher Baker Foundation for the period from February 12 to June 1, 1929, is Dr. F. M. Jaeger, professor of chemistry in the University of Groningen, Holland. Professor Jaeger's introductory public lecture was delivered in the Baker laboratory on the evening of February 12 on: "The Present and Future State of Our Natural Resources." His regular lectures during the term will deal with two main topics: (1) "The Relations between Geometrical and Some Physico-Chemical Properties of Atomic Systems" and (2) "Methods, Results and Problems of High-Temperature Precision Measurements."

PROFESSOR G. H. PARKER, director of the Harvard Zoological Laboratory, has been made a corresponding member of the Société de Biologie, Paris.

DR. W. J. HUMPHREYS, of the U. S. Weather Bureau, has been elected a corresponding member of the Meteorological Society of Hungary.

THE gold medal of the Royal Astronomical Society, London, has been awarded to Professor Ejnar Hertzsprung, of Leyden Observatory, for his work in stellar astronomy.

DR. BERNARD NOCHT, of the University of Hamburg, has been elected a corresponding member of the Royal Society of Medicine, London, in the section for tropical diseases.

THE Geological Society, London, has made annual awards as follows: The Wollaston medal to Professor F. J. Becke, of Vienna, in recognition of the value of his researches in petrology; the Murchison medal to Dr. C. A. Matley, in recognition of the value of his researches on stratigraphical geology in various parts of the British Empire; the Lyell medal to Dr. A. Morley Davies, in recognition of the value of his researches in invertebrate paleontology; the Bigsby medal to Professor P. G. H. Boswell, for his valuable researches in sedimentary petrology and stratigraphy; the Wollaston Donation Fund to Dr. R. Campbell, in recognition of the value of his researches in Scottish petrology and stratigraphy; the Murchison Geological Fund to Mr. L. R. Cox, for his valuable researches in invertebrate paleontology, especially in connection with the Lamellibranchiata; a Lyell Geological Fund to Mr. C. Edmonds, in recognition of the value of his researches on the Lower Carboniferous rocks of the Whitehaven district; a second Lyell Geological Fund to Dr. E. O. Teale, for his contributions to the geology of Victoria and of Africa.

DR. A. HOYT TAYLOR, chief of the United States Naval Radio Research Laboratory at Bellevue, D. C., was installed as president of the Institute of Radio Engineers on February 6 at the institute headquarters in the Engineering Societies Building, to succeed Dr. Ralph Bown. Alexander Meissner, head of the Telefunken Research Laboratory in Germany, is the new vice-president.

THE *Journal* of the American Medical Association reports that Dr. Sigismund S. Goldwater has announced his resignation as director of Mount Sinai Hospital, New York City. He will hereafter be

associated as consultant to the board of trustees. Dr. Goldwater will in the future give his professional attention exclusively to the planning of hospitals, an occupation which has absorbed the greater part of his time since he resigned as health commissioner of New York in 1915.

AFTER having been associated with the University of Melbourne for nearly twenty-three years, Professor R. J. A. Berry, dean of the faculty of medicine, has tendered his resignation of the chair of anatomy to the council, and in recognition of his valuable services has been granted six months' leave of absence, commencing in August, 1929.

O. E. KLINGAMAN, formerly director of university extension of the State University of Iowa, has been appointed assistant director of the Davenport Public Museum, the present name of the old Davenport Academy of Sciences. Edward K. Putnam, for many years acting director, becomes director.

DR. JAMES G. HORSFALL, a graduate student at Cornell University, has been appointed associate in research in plant pathology at the New York State Agricultural Experiment Station at Geneva to make a special study of the diseases of canning crops.

PROFESSOR BRISTOW ADAMS, of Cornell University, was elected one of the directors of the Association of Agricultural Magazines at the national meeting held at the University of Wisconsin.

DR. FRANK E. LUTZ, curator of insect life at the American Museum, has been made a member of the committee on experimental animals and plants recently appointed by the National Research Council. The functions of the committee are to make arrangements for central supplies of animals and plants of known value in experimental biology and to test hitherto unused species of promise.

DR. C. HAMPSON JONES, health commissioner of Baltimore, has been elected director of the National Tuberculosis Association.

THE Phi Rho Sigma Medical Fraternity has granted from its research fund the sum of three hundred dollars to Carlos I. Reed, assistant professor of physiology at the Medical School of the University of Illinois, to aid in his study of the physiological effects of light.

DR. T. E. ODLAND, associate professor of agronomy at the West Virginia University and associate agronomist at the experiment station, has been appointed agronomist at the Rhode Island Agricultural Experiment Station. The former agronomist at Rhode Island was Dr. B. L. Hartwell, who resigned in September.

PROFESSOR A. RICHARDS, of the University of Oklahoma, has leave of absence to study at the Naples Zoological Station during the spring months. He will spend the summer in Austria and Germany, returning at the beginning of the next academic year. During his absence Dr. A. O. Weese will act as head of the department of zoology and director of the Biological Survey.

DR. D. C. CARPENTER, associate in research in chemistry at the New York State Agricultural Experiment Station at Geneva, has returned from a year's leave of absence on a fellowship from the International Education Board. Dr. Carpenter spent most of his time in the laboratory of Dr. Svedberg, of the University of Upsala, in the study of the casein molecule with the aid of the centrifuge built by Dr. Svedberg.

DR. AND MRS. N. L. BRITTON have left New York for Porto Rico to continue their studies of the flora of that island. By going earlier than usual they expected to be able to see something of the vegetation of the southern side of the island before the advent of the dry season.

DR. A. J. GROUT, bryologist, will be at the Biological Laboratory at Cold Spring Harbor this coming summer from June 29 to July 13 for work on the identification and ecological relations of the moss flora of the region.

DR. THEODOR REHBOCK, professor of hydraulics in the Technische Hochschule at Karlsruhe, an authority on river flow and river control, is expected in the United States, arriving on March 16. He will give a series of lectures at the Massachusetts Institute of Technology.

TWO British expeditions are going to the east to observe the total eclipse of the sun on May 9. One headed by Dr. John Jackson, chief assistant at the Royal Observatory, will proceed to Alor Star in the Malay Peninsula. The second, led by Professor F. J. M. Stratton, of the University of Cambridge, will go to Pattani in southern Siam.

DR. WADE H. BROWN, member of the Rockefeller Institute for Medical Research, New York, will deliver the fifth Harvey Society Lecture at the New York Academy of Medicine, on February 21. His subject will be "Constitutional Variation and Susceptibility to Disease."

PROFESSOR W. B. SCOTT, head of the department of geology at Princeton University, lectured on February 4 before the section of geology and mineralogy of the New York Academy of Sciences on "The Former Land Connections of South America."

PROFESSOR WILDER D. BANCROFT, of Cornell University, addressed the technical section of the Canadian Pulp and Paper Association on January 25 at its annual conference at Montreal, Canada. His subject was "Science and Cellulose."

DR. LEONOR MICHAELIS, of the Johns Hopkins University, spoke on "Physiological Applications of Oxidation-Reduction Potentials" on February 7 at the American Museum of Natural History. An informal dinner was held before the lecture.

PROFESSOR HOWARD B. LEWIS, head of the department of biochemistry in the University of Michigan, has accepted the invitation of the biochemical society of Jefferson Medical College to be the next speaker in the series of physiological chemical lectures given each autumn. Former speakers in this series are: Drs. Gies, Columbia; Stockard, Cornell; Wells, Chicago; Shipley, the Johns Hopkins, and Sherwin, New York. Dr. Lewis's lecture will be the first given in the new college building now under construction.

DURING February and March members of the geological faculty of the State University of Iowa are giving a course of lectures at the Davenport Public Museum on the "Geological Past of Iowa," as follows: February 4, "The Ice Age and the Geology of Iowa," Dean George F. Kay; February 14, "The Ice Ages of Iowa," Dean Kay; March 4, "Life in the Past Ages of Iowa," Professor A. O. Thomas; March 18, "The Mississippi River," Professor Arthur Trowbridge. In connection with the lectures a special geological exhibit was arranged with the aid of C. H. Belanski, research assistant at the university.

DR. C. A. HEILAND, professor of geophysics at the Colorado School of Mines, Golden, Colorado, will give a series of lectures in geophysical prospecting at Columbia University. The courses will comprise torsion balance, magnetometer, seismograph and electrical prospecting, and will be given from the beginning of February up to the middle of March.

DR. S. A. GOUDSMIT, of the University of Leiden, lectured before the Franklin Institute on January 31 on "The Atomic Model in Modern Physics," and on February 7 Dr. Elmer O. Kraemer, of the E. I. du Pont de Nemours and Company, spoke on "Some Current Problems in Colloid Science."

A. W. BICKERTON, professor emeritus of astronomy at Canterbury College, University of New Zealand, died in London on January 31 at the age of eighty-seven years.

PROFESSOR RICHARD HENRY YAPP, Mason professor of botany in the University of Birmingham, died on January 22 at the age of fifty-seven years.

WALTER BURT ALCOCK, the mathematician, senior fellow of Emmanuel College, Cambridge, died on January 18 at the age of seventy-one years.

PROFESSOR SICARD, of the Paris faculty of medicine, died on January 28 at the age of fifty-five years. He had devoted most of his life to the study of nervous diseases.

THE death is announced of Dr. Piero Giacosa, occupant of the chair of pharmacology in the University of Turin.

DR. E. L. MARK, director of the Bermuda Biological Station for Research, writes that biologists with definite research problems can be accommodated for a moderate sum at the Bermuda Biological Station for Research during June and July this summer. Detailed information will be furnished on request. Applications should be sent to Professor Mark, at 109 Irving Street, Cambridge, Mass., on or before April 20.

THE committee on scientific research of the American Medical Association invites applications for grants for aid in research on problems bearing on clinical medicine. Inquiries may be addressed to the committee at 535 North Dearborn Street, Chicago. During 1928 this committee made twenty-two grants, the total amount granted being about $12,000.

THE ninth summer term of the American School of Prehistoric Research, under the direction of Dr. George Grant MacCurdy, of Yale University, will open in London on July 1 and close on the continent early in September. The purpose of the school is to fit students to teach, to do field work and research in prehistory, and for museum positions. Undergraduates as well as graduate students and faculty members of universities and colleges are admitted.

UNIVERSITY AND EDUCATIONAL NOTES

THE University of Chicago announces recent gifts to a total of $500,000 toward the support of the University Clinics over a five-year period beginning July 1, 1929. Of this amount $125,000 each has been pledged by Max Epstein and Albert D. Lasker, and $250,000 by the Julius Rosenwald Fund. The gift of the Julius Rosenwald Fund is conditioned upon the university's securing from local sources pledges amounting to $250,000 in addition to the gifts now announced. Dr. Franklin C. McLean, professor of medicine at the university since 1923, has been appointed as director of University Clinics. As a part of the duties of this new position he will assist the president in the medical affairs of the university.

JACKSON JOHNSON, late chairman of the board of the International Shoe Company, has bequeathed $250,000 to Washington University Medical School as a fund to aid students.

THE issue of SCIENCE for February 1 contained a note relating to the gift of Mr. John D. Rockefeller, Jr., to the laboratory of anthropology at Santa Fe. It was there stated that the gift was made to the University of Chicago, whereas the university is only one of several institutions participating in the work.

ASSEMBLYMAN JAMES R. ROBINSON, of Ithaca, has introduced a bill in the legislature providing $1,000,000 for the construction of a home economics building at Cornell University.

BY the will of the late William Lyman Underwood, the sum of $20,000 is left to the Massachusetts Institute of Technology for the benefit of the biological department, with which he was connected for many years.

DR. HAROLD LINDSAY AMOSS, associate professor of medicine of the Johns Hopkins School of Medicine, has been elected professor of medicine at Duke University.

DR. J. V. HOFMANN, assistant director of the Pennsylvania State Forest School, has been appointed head of the division of forestry at the State College of North Carolina at Raleigh, N. C.

M. LÉON BRILLOUIN, assistant director of the laboratory at the Collège de France, has been appointed the first incumbent of the new chair of theoretical physics at the Sorbonne.

DISCUSSION

ON THE PRESENCE OF ALUMINUM IN PLANT AND ANIMAL MATTER

IN an article entitled, "A Study of the Possible Rôle of Aluminum Compounds in Animal and Plant Physiology," by E. V. McCollum, O. S. Rask and J. Ernestine Becker, published in the *Journal of Biological Chemistry*, Vol. 77, p. 753, 1928, these authors arrived at the conclusion that aluminum is not a constituent of either plant or animal matter. Since this conclusion is so contrary to what has been found by practically all previous investigators, we have checked the work of McCollum and coworkers in the laboratory and have found that they are quite in error. Using the Hilger quartz prism spectrograph, as they did, we found aluminum to be present in egg, potato, carrot, English walnut meat, peach pit, apricot pit, pop-corn, lima bean, navy bean, lupine bean, peanut kernel, lean beef, beef tendon and human cancerous tissue excised from the breast by the surgeon. The complete experimental details will soon be ready for publication.

LOUIS KAHLENBERG,
JOHN O. CLOSS
CHEMICAL LABORATORY UNIVERSITY OF WISCONSIN, MADISON, WISCONSIN,
FEBRUARY, 1929

TO DEMONSTRATE THE COURSE OF SAP ASCENT IN PLANTS

THE usual methods for demonstrating the course of the ascending sap stream, or transpiration stream, through the wood of the vascular bundles of land plants, are open to manifest objection. The commonest method—that of allowing an amputated plant or branch to draw up a colored solution (*e.g.*, red ink) through the cut end—is undesirable because of the tendency of the dissolved pigment either to diffuse or to attach itself to *ad*sorbent walls. The usual alternative to this—a suspension of insoluble particles such as finely ground India Ink, which is also drawn up by the ascending sap stream—while it carries admirably, is also objectionable because it does not stay in place when one attempts to make sections of the tissues into which it has been drawn. One may engage in the time-consuming processes of fixing, imbedding, microtome sectioning, etc., in order to avoid dragging or scattering the carbon by the knife or razor-blade.

But it has occurred to me that one may have the advantages of a non-diffusing suspensoid without the risk of dislocation by sectioning, if one use a suspension of finely ground starch. This innocuous material will also be drawn up through the ducts. When the process has continued as far as one wills, the granular starch may be fixed in place by subjecting the plant or branch to sufficient heat to make paste. The part may then be sectioned, stained with iodine, and examined. The starch will be found to be more or less completely filling the ducts.

Experiment made by Mr. Edwin D. Woodhouse, one of our graduate students, showed that starch was drawn up through six internodes by castor bean (*Ricinus communis*) branches in about twenty-four hours, and that it was drawn through six inches of leaf stalk in about half an hour, in the warm dry air of the laboratory. While Mr. Woodhouse and I are proceeding with our investigation of what he has called sap hydraulics, presently publishing our results elsewhere, I believe this method is so remarkably useful for demonstrations that I should be glad to have it used in this way while we are testing it in others. It is obvious that we shall be able, by using

starch of suitable fineness, to test the powers of the different parts of the conducting systems of vascular plants, determining by the presence of starch the course of the streams, the cells actually used, whether some or all the constituents of a vascular bundle are employed, etc. In this way we may also be able to throw the light of facts upon the disputed subject of the energetics of sap ascent.

GEORGE J. PEIRCE

STANFORD UNIVERSITY,
CALIFORNIA,
DECEMBER 15, 1928

RING METHODS FOR SURFACE TENSION MEASUREMENTS

IN recent years there have appeared a number of papers treating of the ring methods employed for the measurement of surface tension. Most of those that have appeared in this country have been concerned more particularly with the Du Noüy tensiometer, and have ignored the fact that that instrument might conceivably be used for either of two distinct methods.

As a ring is slowly raised from an extended surface of a liquid that wets it, the resultant downward pull of the liquid passes through a distinct maximum, and, if the ring is not too small,[1] it then reaches a lower and constant value before rupture occurs. These changes have been described and explained by Sondhauss,[2] Hall,[3] Lenard,[4] Fahrenwald,[5] and others. Reducing the thickness of the ring reduces the difference between the constant and the maximum pull.

The surface tension may be derived from either of these values of the pull, but the procedures differ. As the maximum pull is the least that will suffice to detach the ring from the liquid, the method based on it may be called the ring detachment method. The lower and constant pull, observed when the ring is raised sufficiently higher than the position of maximum pull, corresponds to the existence of a true double film between the liquid and the ring, and the method based on it may be called the ring film method. In the detachment method, a portion of the pull arises from the suction exerted by the column of liquid, in bulk, pendent from the ring and extending from it to the main body of the liquid. In the film method, a portion of this column has been replaced by the film, and only the weight of the small portion lying above the top of the film contributes to the pull, the rest of the pull being due to the film itself.

In practice, the ring is suspended from the arm of a torsion, or other, balance by which the pull exerted by the liquid is measured. If the balance is pliant, so that the force exerted by it varies very little with the elevation of the ring, and if the motion of the ring is not suitably restricted, then rupture will occur when the maximum pull is reached. But if the balance is stiff, then the rise that occurs as the ring passes the position of maximum pull may relax the balance sufficiently to restore equilibrium, and then a further adjustment is required in order to produce rupture; this adjustment draws out the true film, and the pull registered at rupture will be that corresponding to the film method. By suitable care and control of the motion of the ring, either method can be realized with either type of balance, but without such care and control each balance favors one method rather than the other.

Before data obtained by such an instrument can be satisfactorily discussed and interpreted, it is necessary to know by which of these methods they were obtained. Each experimenter should determine and clearly indicate the method employed. The absence of such indication detracts greatly from the value of the work, and compels the reader to infer the method from a consideration of the manner in which the instrument has been most frequently used by others. Unfortunately, it seems impossible to determine with certainty from the published papers whether the Du Noüy tensiometer usually functions as a detachment or as a film instrument. In the paper[6] describing his first instrument, Du Noüy regards the method as a mere refinement of that of Weinberg,[7] which was a detachment method. But in a later account[8] of the origin of the instrument, he groups the method with that of Sondhauss (film) as well as with that of Timberg and of Weinberg (detachment). In his study of the instrument, Harkins[9] speaks definitely of measuring the maximum pull, thus showing that he used it as a detachment instrument. Klopsteg[10] classes the method with that of Weinberg (detachment), but a little further along he says that at a certain stage before rupture occurs "the liquid adher-

[1] Its internal diameter must be no less than that of the tube in which the liquid will rise to a height equal to the elevation of the ring when the pull is a maximum.

[2] C. Sondhauss. Pogg. Ann., Erg. Bd. 8: 268–298; 1878.

[3] T. P. Hall. *Phil. Mag.* (5), 36: 385–413; 1893.

[4] Lenard, v. Dallwitz-Wegener, and Zachmann; *Ann. d. Physik*, 74: 381–404; 1924.

[5] A. W. Fahrenwald. *J. Opt. Soc. Am. and R. S. I.*, 6: 722–733; 1922.

[6] P. L. Du Noüy. *J. Gen. Physiol.*, 1: 521–524; 1919.

[7] B. Weinberg. *Zeits. f. physik. Chem.*, 10: 34–50; 1892.

[8] P. L. Du Noüy. "Surface Equilibria of Colloids," p. 23, Chemical Catalog Co., New York, 1926.

[9] Harkins, Young and Cheng, SCIENCE, 64: 333–336; 1926.

[10] P. E. Klopsteg. SCIENCE, 60: 319–320; 1924.

ing to the ring is suddenly drawn out into a thin annular film, several millimeters long, yet retaining stability." This strongly suggests that the film method was the one actually realized.

Although I have not used the Du Noüy instrument, I am inclined to believe that the film method is the one most frequently realized. But, until the confusion just indicated has been removed by the publication of the results of a careful, detailed study of the behavior of the instrument, it is not possible to speak with certainty regarding it. That study should include a description of the essential features of what occurs during the process of tearing the ring from the liquid, as well as adequate numerical data.

The factors that must be considered in the reduction of observations obtained by means of the detachment method have been discussed by Weinberg, Cantor,[11] Lenard, Tichanowsky,[12] and others. They involve the inclinations of the liquid surfaces where they meet the ring, and the suction of the pendent column. No satisfactory, theoretical formula for computing any of these quantities has yet been derived, but Harkins has published empirical curves from which the surface tension can be deduced from the observed maximum pull on wire rings of certain sizes. Owing to the absence of such formulae, Weinberg had to make a number of assumptions in the reduction of his observations, and additional complications were introduced by the crossed diametral strips with which he braced his ring. The abnormally high value that he deduced for the surface tension of water is to be sought in errors in these assumptions. It certainly is not due, as has been suggested,[10] to an omission of the very elementary and well-known correction for the inclination of the balance beam at the instant of rupture, for he not only described in some detail the mirror system by which he determined the position of the beam, but also discussed this correction, which, in his case, was small.

In the film method, it is necessary to consider the effective radius of the tubular film, and the weight of the liquid lying between the ring and the top of the film. These have been discussed by Sondhauss, Lenard, and others, and Sondhauss has called attention to the fact that the form of the film suggests a portion of an inverted cone. Again satisfactory formulae are lacking, and empirical curves similar to those determined by Harkins for the detachment method would be of value.

N. Ernest Dorsey

National Research Council,
Washington, D. C.

[11] M. Cantor. *Wied. Ann.*, 47: 399–423; 1892.

[12] I. I. Tichanowsky. *Physik. Zeits.*, 25: 299–302; 1924; 26: 522–525; 1925.

POSSIBLE WATER SUPPLY FOR THE CREATION OF CHANNELED SCAB LANDS

The creation of the channeled scab lands in eastern Washington has been the subject of much discussion. Dr. J Harlen Bretz, of the University of Chicago, describes the formation of the channels, and the sweeping away of the loess that once occupied the surface, as being done in a short period of time with a huge volume of water, all channels being at high flood at one time with sufficient water flowing across country to cause the Columbia River to rise nine hundred feet at Wallula Gap, where the channel is about a mile wide between basalt bluffs.

A means of providing this volume of water, approximately fifty cubic miles per day, has puzzled Dr. Bretz and other geologists interested in the phenomenon. Dr. Bretz gives two possible explanations of such a flood: first, that the glacier was melted excessively in a short period of time by extreme heat and warm rains; or second, that the Spokane flood was a gigantic Jokulloup, such as has occurred in Iceland where volcanic activity has broken out beneath an ice-cap.

I am more inclined to believe that the flood was caused in a more natural and regular way, by the ponding of waters in natural reservoirs by ice obstructions.

The essential factors necessary to supply a sufficient amount of water to cause the channeled scab lands are as follows: first, a secure ice dam in the Columbia River below the Nespelem River to divert the water across the eastern Washington table-land; second, a reservoir large enough to hold a sufficient amount of water; third, a temporary dam sufficiently high to impound the water; fourth, water to fill the reservoir.

When the glacier was farthest advanced, probably its southern boundary was about as follows: commencing near Wenatchee, Washington, the extreme southwest corner of the Okanagan Lobe; thence, extending across the Columbia River, following the basalt bluffs along the west side of Badger Mountain; thence, along the north slope of the Big Bend plateau to near the upper end of Grand Coulee; thence, across the Columbia River near the mouth of the Nespelem River; thence, in an easterly direction, again crossing the river in the vicinity of Inchelium; thence, in a southeasterly direction, crossing the Spokane River and extending possibly to Spangle, the southern terminus, forming the Spokane Lobe; thence, in a northeasterly direction along the north and west slope of the Coeur D'Alene Mountains to Clark's Fork; thence, southeasterly, following Clark's Fork through the Bitter Root Mountains, completely damming the Clark's Fork Canyon through these mountains; thence, in a northeasterly direction to

the base of the Rocky Mountains, forming a third lobe on the southeasterly corner.

From near Wenatchee to somewhere near the mouth of the Nespelem, the Columbia was obstructed with a continuous ice dam that withstood the impact of the Spokane flood, which probably occurred soon after the glacier reached its farthest point of advance. We will designate this obstruction as the Okanagan Dam. The Okanagan Dam created a lake, if not named before, to be known as San Poil Lake. This lake occupied the southeast corner of the Colville Indian Reservation, commencing at a point near the mouth of the Nespelem, and covering the land along the river where the elevation did not exceed that of the Grand Coulee Divide, and extending up river to the lower edge of the glacier.

From the lower edge of the glacier near Inchelium up to Clark's Fork, all of the Columbia River Basin in Canada, and the basin of Clark's Fork in Idaho to the Montana line, were covered with glacial ice to a depth of three thousand feet or more, thereby damming up the Columbia from Inchelium to the Montana line. To this obstruction we will give the name Spokane Dam.

It is evident from the above that the glacial ice occupied all the places for ponding water in the Columbia River watershed in Canada, and practically all the basin of Clark's Fork and the Kootenai in northern Idaho, but that the entire area of Clark's Fork and a portion of the Kootenai watershed in Montana, consisting of about twenty thousand square miles, was unoccupied by ice.

This unglaciated area was bounded on the north by the ice barrier, on the east and south by the Rocky Mountains, and on the west by the Bitter Root Mountains, thereby creating a reservoir known as Missoula Lake, which was filled with water to an elevation of about forty-two hundred feet.

All passes through these mountain ranges have a higher elevation than the Missoula Lake level, excepting that portion occupied by the ice barrier that existed in Clark's Fork Canyon through the Bitter Root Mountains.

During this period of the existence of the glacier, the Okanagan Dam played only a minor rôle, ponding the waters of the San Poil Lake and the waters of the Okanagan watershed. But the Spokane Dam ponded all the waters to the east, north and southeast of the junction of the Columbia and Clark's Fork.

The duration of the Spokane Dam was from the time the glacier advanced from the mouth of Clark's Fork to near Spangle, possibly one thousand years, and an additional length of time to allow the filling of Missoula Lake to an elevation of about forty-two hundred feet. The present annual rainfall in the area occupied by Missoula Lake is from fifteen to twenty inches and during the glacial period was probably more. Should we accept eighteen inches per annum as the average, then, during the one thousand years of advance of the glacier from the mouth of Clark's Fork to Spangle, we would have fifteen hundred feet of rainfall over the entire twenty thousand square miles of the Missoula Lake watershed. Allowing fifty per cent. of this rainfall for evaporation, seepage and dam leakage, we would have approximately twenty-eight hundred cubic miles of water ponded in Missoula Lake. Undoubtedly the dam gave way long before the recession of the glacier, for this amount of rainfall would fill Missoula Lake to the overflowing point long before the estimated stationary period of the glacier had elapsed.

The area for ponding water in the Missoula Lake Basin is limited on account of the high elevation of the southern end and the numerous mountain spurs extending into the basin. But, I am satisfied, the area was continuously enlarged as soon as the glacier ceased to advance, for at all points along the ice barrier in Montana where the glacier encountered the warmer waters of the lake, undercutting on the front of the glacier caused caving, and huge icebergs floated around in the lake and melted away, adding an additional supply of water to the annual rainfall.

It is also possible that the surface of the eastern slope of the glacier next to the Rocky Mountains was below the forty-two hundred foot level, which would allow Missoula Lake waters to cover and melt the glacier over the Kootenai Lake area in Canada, thereby greatly enlarging the volume of water that was impounded in Missoula Lake.

Undercutting by the lake waters probably caused the dam of ice to recede gradually through the Bitter Root Gorge, thereby allowing Missoula Lake to occupy a part of the area of the Clark's Fork watershed, west of the Bitter Root Mountains, possibly as far west as the present Pend D'Orille Lake in Idaho, before the Spokane Dam gave way.

When the Spokane Dam gave way soon after the last period of advance, the glacier's surface must have been uneven, broken and badly jumbled, for it had advanced through an extremely mountainous region, many peaks of which extended above the surface of the glacier. At its southern terminus, south and east of Pend D'Orille Lake, the ice probably piled high up on the northern slope of the Coeur D'Alene Mountains, leaving a ragged, elevated edge. Under such conditions, when the water found an outlet over the glacial obstructions, the flow could have occurred at any point in the area occupied by Pend D'Orille Lake, instead of following the southern rim of the

glacier as it would have done if the break had occurred when the glacier was receding and its edges clear.

If the above hypothesis is right, it is evident that the escaping flood can pass to the north and west of Spokane and distribute itself over the glacier, wearing several channels in the ice to the glacier's edge, some of which deposited their water into San Poil Lake to fill and enlarge the preglacial channel known as Grand Coulee. Through other ice channels, the glacial water was poured over the rim of the glacier to fill, enlarge and widen all the then existing preglacial channels, and, in many instances, to form in the scab lands new channels of large dimensions.

It is the belief of the writer that during the different glaciation periods many floods occurred which were produced in a similar manner. Whenever large volumes of ponded water were released and passed through the well-eroded preglacial channels, they deposited along the main preglacial channels large gravel bars, some of which were miles in length, and from one hundred to two hundred feet in depth. These gravel bars were formed across the outlets of channels entering the main drainage channels, and could not be formed if the water flow in the side channels were simultaneous with the flow in the main channels. If the water flow in the side channels were simultaneous, there would be no opportunity for gravel bars to form across the mouth of the side channel at an elevation higher than its bed. The entrance to the side channel must have been filled by backwater from the main channel, thereby allowing the bars to be deposited across its front in comparatively quiet water.

H. T. HARDING

WALLA WALLA, WASHINGTON

BLOOD RELATIONSHIP WITHIN THE ORDER RODENTIA

IN his classic study of phylogeny by means of precipitating antisera Nuttall left untouched the problem of the blood relationship of the rodents. The present serological study of the four species of mice, *Mus musculus, Mus wagneri, Mus faroensis* and the Japanese waltzing mouse of the genus *Mus,* was begun with an attempt to produce precipitating antisera in pigeons, using the serum or muscle extracts of these rodents as antigens. In spite of all modifications in manner of treatment of the birds the study of two hundred pigeons has not given an antiserum which would differentiate these mice. Several antisera have been obtained which reacted up to dilutions of 1:50 and 1:100, but these show a very broad reaction among the rodents and are absolutely non-specific in regard to the differentiation of the four types of mice considered. Similarly Nuttall failed to obtain any precipitin from the serum of a duck and a chicken treated with rabbit serum. Several workers, however, have considered that such an antiserum may be produced.

Recently, acting upon the suggestion of Dr. F. G. Novy and following the work of Uhlenhuth and Weidanz (1909) and R. Trommsdorf (1909), rabbits have been immunized against the serum of *Mus musculus.* By a modification of Nuttall's quantitative method of precipitin titration the blood of *Mus musculus* could readily be differentiated from that of Japanese waltzing mice and *Mus wagneri.* Serologically, the *Mus faroensis,* however, may be regarded at present as identical with *Mus musculus.* For these titrations precipitating antisera from the rabbit were used. These gave definite reactions at dilutions of antigen as high as 1:10,000 and in every instance the end point in the titration of *Mus faroensis* was the same as that of the homologous antigen, *Mus musculus.* Likewise *Mus wagneri* and the Japanese waltzer react to the same point, but this is always at a definitely lower level than the one at which *Mus musculus* and *Mus faroensis* were found positive. For example, in the case of a precipitating antiserum which reacted with *Mus musculus* and *faroensis* at 1:6,500, the Japanese waltzer and *Mus wagneri* consistently remained active only up to 1:4,000, and again with an antiserum active against *Mus musculus* and *Mus faroensis* in dilutions up to 1:10,000, Jap waltzer and *wagneri* were positive only in dilutions up to 1:4,500. With these antisera rat serum was active only in dilutions up to 1:100, a logical group reaction.

It was feared that rabbits might not be suitable animals for the production of rodent antisera, inasmuch as several investigators have considered that they might well contain natural precipitins for other rodents. In an effort to eliminate this factor of error sixty-eight normal rabbits of assorted types and sexes were titrated against both *Mus musculus* and *Rattus norvegicus* at dilutions ranging from 1:4 to 1:5,000 and were found to be consistently negative. In addition all experimental rabbits were tested for the presence of the precipitating antibody in their serum before the treatment was instituted and all final titrations contained controls with normal serum.

At present the pigeon may be considered unsuited for the production of precipitating antisera. The rabbit is free from natural mouse or rat precipitin and is suitable for the production of these antibodies. The four species of mice studied fall into two groups serologically distinct, the one being *Mus musculus* and *Mus faroensis* and the other Japanese waltzer and *Mus*

wagneri. Within either of these groups, as yet, it has not been found possible to make any serological distinction. The study of blood relationship within the order Rodentia is being continued, using both birds and rabbits as antibody producers.

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LUMINESCENCE

I READ with very great interest the article on "The Excitation of Luminescence by the Agitation of Mercury in Glass and Transparent Fused Silica Tubes and Vessels" by W. L. Lemcke in SCIENCE of January 18. At the close of the article it was suggested that it would be of scientific interest to examine the radiations coming from a transparent fused silica vessel with the aid of a spectrograph with quartz prism and lenses. This problem has occupied my time for the past few months. It is my aim to examine, as Lemcke suggests, the effect on the luminescence produced when certain gases and solids are present in the vessel.

Using a standard "Shaker" tube of transparent fused silica and a Hilger E_2 Quartz Spectrograph I was able to record very definitely on a plate the resonance line λ 2537 Å of Hg with exposures as short as forty-five minutes. The tube was 2.5 cms in diameter and had the usual central inner tube. That part of the tube which contained the inner tube and the mercury was 15 cms in length. Only mercury, its vapor and air at very low pressure were present in the tube. A crank on the shaft of a small electric motor gave the tube a horizontal reciprocating motion in front of the slit of the spectrograph, which was distant about 3 cms from the axis of the tube.

A trial exposure of forty-two hours with the same apparatus brought out a great number of lines in the visible region as well as a faint continuous spectrum and a very interesting looking band extending from λ 2537 Å to about λ 2570 Å, where it cut off sharply. Further work is being done on this problem and the results will be published.

Interesting in connection with this problem is the work of Duffieux[1, 2] and of Robertson, MacKinnon and Zinn.[3] The former examined the luminescence produced when an evacuated spherical Pyrex bulb containing a large drop of mercury is rotated, and the latter rolled a drop of mercury on the inside of an evacuated quartz tube in order to produce a continuous mercury spectrum. In both cases the temperature was from 60° to 240° C. I have thus far confined my investigation to temperatures near 30° C.

LOUIS F. BROWN

[1] Duffieux, *Comptes Rendus*, 1927, *184*, p. 1434.
[2] Duffieux, *Jour. de Phys. et le Rad.*, 1928, *9*, p. 61.
[3] Robertson, MacKinnon and Zinn, *J. O. S. A. and R. S. I.*, 1928, *17*, p. 417.

SPECIAL CORRESPONDENCE

THE DANISH CIRCUMNAVIGATION EXPEDITION

IN May, 1904, the Danish research vessel *Thor*, fishing over deep waters west of the Faroes, found a fully grown larva of the common European fresh-water eel. Up to that time corresponding stages were only known from the Straits of Messina, in the Mediterranean. The find led the young fishery biologist, Johs. Schmidt, into whose hands it came, to devote himself to the problem of the eel, and for twenty-five years he has been engaged upon the task. He is now on his way around the globe with an expedition mainly designed to ascertain the breeding grounds of eels all over the world. Endeavors will, however, also be made to elucidate various other oceanographical questions which have arisen during the past twenty-five years of research.

Thus, as so often before in the history of science, an apparently small discovery has led to far-reaching developments; many problems have been solved, and even more have arisen, in the course of the cruises organized by Professor Johs. Schmidt, of the Carlsberg Laboratory, Copenhagen, in connection with his investigations on the eel. During the past twenty-five years, the following expeditions have been sent out from Denmark, with eel investigations among their principal aims; the cost of these expeditions has been defrayed by the Danish government, by the Carlsberg Foundation, by the East Asiatic Company in Copenhagen and by private persons interested in the work.

Thor, 1905–06, in the Atlantic west of Europe.
Thor, 1908–10, in the Mediterranean.
Margrethe, 1913, Europe, West Indies.
Dana I, 1920–21, Europe, West Indies.
Dana II, 1921–22, Europe, South America, West Indies, Panama, West Indies, U. S. A.

The present *Dana* expedition, which is to occupy two years, left Denmark in June, 1928, and is under the patronage of His Royal Highness Prince Valdemar of Denmark.

The route to be followed is as follows, westward around the globe: First to Spain, Portugal and the Straits of Gibraltar, with the western part of the Mediterranean; then via Madeira to the West Indies and on through the Panama Canal into the Pacific, to Tahiti, the Fiji Islands and New Caledonia; thence to New Zealand and Eastern Australia. In the waters east of Australia, two months will be spent, and the

vessel will then proceed, in March, 1929, northward to Japan and China; later, the Malay Archipelago will be visited (Dutch Indies, Siam, etc.); and investigations will then be made in the Indian Ocean along a line from Java to Madagascar. From Madagascar, the course will lie along the East Coast of Africa, and through the Red Sea and the Mediterranean. The expedition is expected to terminate in the spring of 1930. A great part of the route has already been covered, and the *Dana* is now working in the area between the Fiji Islands and New Caledonia. The vessel, which is of 360 tons, is the marine research vessel of the Danish government, but is sent out at the expense of the Carlsberg Foundation; it is equipped with the most modern apparatus for the various forms of deep-sea fishery investigations, as well as the most recent instruments for hydrographical observations, etc. Throughout the voyage, soundings will be taken with an echo-sounding machine, the observations thus covering the circuit of the globe. The vessel is in constant direct communication with Copenhagen by means of a short-wave transmitter.

It will be natural here to give a survey of the historical progress of the special eel investigations which form one of the principal objects of the expedition.

Prior to 1904, it was believed that the breeding grounds of the eel were situated in the Mediterranean; there was nothing to show that it ever bred elsewhere. The expeditions of 1905–06 established the fact that the eels of Scandinavia and those of Western Europe came from the Atlantic. The further work of the 1908–10 expeditions showed that the eel did not breed in the Mediterranean at all, the larvae found there having made their way in through the Straits of Gibraltar. Then came the discovery, on the cruise of 1913, that the eel larvae increase in number and decrease in size (age) from east to west across the Atlantic, leading to the conclusion that the breeding grounds must lie in the western part of that ocean.

Finally, the expeditions of 1920–22 demonstrated the fact that all the eels of Europe spawn only in a restricted area of the Western Atlantic, in the vicinity of the West Indies. From here, the larvae migrate across the ocean, increasing in size until—about three years after their first coming into the world—they appear as elvers ascending into the fresh waters of Europe and Northern Africa. It was further shown that the American eel (*Anguilla rostrata*) has its center of production close to that of the European form, that its larvae occur in the ocean together with those of the European eel, and that the larvae of the two species may be distinguished one from the other by the number of myomeres (vertebrae). In contrast to those of the European, the larvae of the American eel take only one year to accomplish their development, *i.e.*, about one year after birth they make their way as elvers into the fresh waters of North America. The difference in duration of the larval stage as between the European and the American eel, together with the direction of the ocean currents, afforded an explanation as to how the young of the two species, starting from approximately the same point, were distributed to opposite sides of the ocean.

The results of the above-mentioned expeditions show that the biology of the two species of eel found in the Atlantic is of a highly remarkable and differentiated character, especially as regards the European eel, the larval migrations of this species far surpassing anything known among other animal forms. In accordance with this biology, we find that all the millions of eels in Europe and North Africa belong to one and the same race. It is immaterial whether samples be drawn from Iceland, the Baltic or Egypt; no racial difference can be shown to exist between them. The average number of vertebrae is invariably about 114.7 (that of the American eel about 107.2).

It was desirable now to ascertain how the distribution of the fresh-water eel throughout the globe took place, and the biological effect of its larval migrations, often of enormous extent, as contrasted with the highly stationary species of many coastal fishes which have developed into a great number of different races. Accordingly, in 1922, racial investigations to comprise all species of fresh-water eels throughout the globe were entered on the program of the special racial investigations to be carried out by the Carlsberg Laboratory, in the course of which Schmidt has been endeavoring for many years to elucidate various important biological questions.

And in the course of the past five years, the laboratory has procured a very great amount of material of Anguilla from all parts of the world in which the genus is represented.

While serving its original purpose, *viz.*, the racial investigations of the Carlsberg Laboratory, the study of the genus Anguilla and its classification has at the same time given rise to various problems of great interest from the point of view of biological and physical oceanography, providing, moreover, the zoological basis for their solution.

The problems here in question are those of the biology of the Indo-Pacific Anguilla species, especially their migrations (position of the breeding grounds) and the movement of the larvae from the breeding grounds to the fresh waters of the continents, all in relation to the physical conditions of the oceans. It

has already been possible to show that the eels of the Indo-Malayan area, like those of the Atlantic, breed in deep water, though these tropical species do not appear to undertake migrations of so great extent as those recorded from the Atlantic.

The researches of the Carlsberg Laboratory have shown that there are two species of Anguilla in the Atlantic, about six in the Indian Ocean and about twelve in the Pacific, making in all about a score of different species or a little over. These have been further examined in regard to a series of characters, the number of vertebrae in particular, as this feature differs greatly in the different species, and can also be distinguished even in the young larvae, The determination of the number of vertebrae in all the different species has thus provided a means whereby it is possible to identify the separate forms even as tiny larvae floating in mid-ocean. And this again furnishes the zoological basis for solution of the problem as to migration of the species.

In the Pacific, we find a whole series of biological types within the genus Anguilla, the most stationary being the tropical forms, whereas those of the temperate regions (China and Japan in the northern, New Zealand and Southeastern Australia in the southern hemisphere) are, as far as can be seen, migratory, albeit not to the same extent as the European eel.

Among exclusively tropical species we find, for instance, in *Anguilla mauritiana*, which has an enormous range of distribution, that the various populations differ in structure from one locality to another; it is, therefore, most unlikely that they should undertake migrations of any extent; it seems, indeed, as if some species only exist within a certain restricted area (*Anguilla borneensis*).

As regards the temperate species, on the other hand, everything seems to suggest that all these undertake a migration in the direction of the tropics, in order to breed there, the larvae then migrating in their turn, with the aid of the ocean currents, to those same temperate regions whence their forebears had come, and where the growth of the species takes place, in fresh water.

The *Dana* investigations in the Indian Ocean and in the Pacific have now two main objects: (1) to study and map out the distribution of the larvae of the various Anguilla species, and to ascertain in each case, as far as possible, how the different larval stages themselves are distributed; (2) to ascertain the physical and chemical conditions prevailing in the waters concerned, including the currents.

The route of the expedition has been determined beforehand with a view to these eel investigations, but a great number of other problems may also be solved in the course of the work.

Thus, while carrying out the operations necessary for its main purpose, the expedition will—judging from previous cruises of the *Thor* and *Dana*—automatically procure, in the first place, representative collections of the pelagic fauna, and, further, a general view of the physicochemical conditions in the waters traversed.

Some of the researches which have been or will be undertaken by the expedition in this direction may here be noted.

The study of the oxygen content in the deeper layers of the Pacific and the Indian Ocean, which may be said to have originated from the investigations of the *Dana* in the Gulf of Panama[1] in January, 1922, is of great general importance, and a survey of the distribution of oxygen will be most valuable as an indication of where the bottom water of the Pacific is formed, as well as for the understanding of the currents generally, or movements of the water at deep levels in both the oceans mentioned. The quantities of nitrates, etc., in the sea water will be investigated throughout the entire circuit of the globe.

As noted above, the topography of the sea floor will be studied in the Atlantic, Pacific and Indian Oceans by means of echo soundings. Particular attention will here be devoted to an investigation of the deep basins in the Pacific east of Australia and New Guinea, both as regards their topography and hydrography (by temperature and other observations, and drift bottles for current measurement).

Hydrographical sections will, as already apparent, be taken throughout the route. In the Straits of Gibraltar, especially, attention will be devoted to the interchange of water between the Atlantic and the Mediterranean; in the Straits of Bab-el-Mandeb, likewise, as between the Red Sea and the Indian Ocean.

The expedition will have abundant opportunities to procure material of pelagic organisms from the different oceans, and thus furnish important contributions to the zoogeography of the oceanic regions, for comparison between the pelagic animal communities of the different oceans, and for a further extension of the classification of many groups of pelagic fauna, as has already been done by the expeditions previously mentioned in the case of the Mediterranean and Atlantic.

The expedition will also be able to obtain a survey of the quantitative distribution of plankton in the waters traversed.

In the waters of New Caledonia, where a stay of some duration will be made, it will be possible to make closer investigation of the fauna of the sea

[1] *Cf.* Johs. Schmidt, "On the Contents of Oxygen in the Ocean on Both Sides of Panama," SCIENCE, June 5, 1925.

floor, partly by means of the bottom-sampler, partly by dredging and trawling.

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REPORTS

BATHYGENETIC AND OROGENETIC MOVEMENTS

PROFESSOR ALBRECHT PENCK, of the University of Berlin, addressed the Boston Geological Society in the North Hall of Walker Memorial at the Massachusetts Institute of Technology on Friday evening, September 28, 1928.

That a period of mountain making generally follows the formation of geosynclines, in which a great thickness of rocks was deposited in a gradually sinking basin, was an old idea originated by James Hall and further advanced by the studies in the Appalachian region. In the Bavarian Alps a limestone formation occurs, known as the Wettersteinkalk. It is of Lower Triassic age, and although it has a thickness of five thousand feet, it shows no important change from bottom to top. It represents deposition in a shallow sea, the bottom of which was slowly subsiding. The Wettersteinkalk is covered by the Raibl shales, which are in turn overlain by the Upper Triassic Haupt Dolomite, a formation also about five thousand feet thick. The thickest part of the Haupt Dolomite is offset geographically from the thickest part of the Wettersteinkalk, so that the great limestone masses form overlapping lenses. The whole thickness of the Haupt Dolomite also consists of deposits formed in shallow water, thus implying continuous subsidence. This type of progressive subsidence Penck called "Bathygenetic movements."

Walcott found evidence of similar movements in the northwestern part of the United States during his study of the Cambrian rocks. These rocks were formed in separate basins that continuously sank during the period of deposition. When bathygenetic movements occur successively at different times and the area of maximum depression shifts or migrates from one locality to another, the large lenses of sediments will be found either with overlapping edges or in separate basins.

An important observation in the Bavarian Alps is that the Raibl strata contain pebbles of Wettersteinkalk, indicating that sufficient elevation followed the sinking of the geosyncline to allow a conglomerate to form. The structure of the Wettersteinkalk is complex, but since the Raibl beds are horizontal, a compression must have followed closely upon the bathygenetic movements.

Professor Penck had just come east from a summer at the University of California where he had become familiar with the geology around Berkeley. There the Orinda formation of the Coast Range has a thickness of about five thousand feet, but its geographical extension is a very narrow one, being only ten to fifteen miles wide. The formation, which consists of clay, conglomerate and sands that were deposited in very shallow water, is of Upper Miocene and early Pliocene age. In the vicinity of Berkeley there are some other more recent formations also of narrow width and of great thickness. West of Berkeley, however, the Jurassic Franciscan formation is found, and no more Pliocene rocks are met until San Francisco is reached. There seem to have been two blocks, separated by north-south faults; the western one, containing the Franciscan rocks, was being elevated while the eastern one was sinking. Into the basin so formed, the material derived from the erosion of the elevated western block was deposited. Thus the Orinda formation was made.

The manner of deposition of the Orinda differs from that in geosynclines, which are structures of wide extent, and indicates the sinking to very considerable depths of very narrow belts. As to the cause of such sinking there are varying opinions. One view is that the basin is of synclinal form, while another is that the sinking block is bounded by faults and represents a graben. Professor Penck believes that the block was not pushed down by the sediments as they were deposited, but that the sinking took place by the movement of the underlying block, and into the trench so made the detritus was deposited. Another observation bearing on this same problem was made by Walcott, who noted that each sinking basin has its own individual succession of strata.

In no place are the Orinda beds horizontal, and all have been considerably disturbed. This disturbance followed closely on the deposition, as in the case of the Wettersteinkalk in the Bavarian Alps.

Returning to a discussion of the European locality Professor Penck noted that the chain of the Alps is bounded by the Alpine foreland, in which there is a great thickness of Miocene formations, several thousand feet in total, although elsewhere the deposits are not thick. Fifty years ago he made a study of this Alpine foreland, and found that although the lower strata could not be followed, one upper layer was sufficiently unique to trace, which he did with Franz Edward Suess. This layer, although somewhat tilted, is nearly horizontal. During the World War some drilling for coal and oil gave the opportunity to study the underlying strata. Bore holes, one of which was four thousand feet in depth, showed that all the underlying strata are inclined about 20 degrees. This indicates that the lower part was disturbed while the upper was not, and proves that the crustal movements

went on during the deposition of the series. This is evidence that folding goes on in depth.

The formation of a geosyncline goes on together with considerable compression. Thus one can understand how the narrow troughs in California, like that in which the Orinda was deposited, have been so greatly compressed. If a layer is compressed, it must lose in width what it gains in thickness. As a consequence, although not a necessary one, the deposit may be pressed up and elevated. Thus as a result of the compression the block containing the Orinda beds was elevated, and now after erosion it forms the Berkeley Hills.

During this erosion a number of terraces were cut, a fact which indicates that several periods of uplift had occurred, causing a corresponding number of erosion cycles.

Professor Penck expressed the view that sinking, compression and elevation have gone on very slowly. There was first the formation of a very gentle anticline, a mere swell, and this was eroded to give an initial peneplain. Continued elevation during erosion produced several phases of leveling. This idea of the sequence of events was advanced by his son, the late Walter Penck.

During the formation of the Berkeley Hills there must have been other vertical movements, since there is a fine development of longitudinal valleys resulting from faults and flexures.

The sequence of orogenetic movements following bathygenetic is proven also in the Alps. Many years before, Professor Penck had made a study of the glacial deposits there. Although he then had an idea that the mountains were formed by folding (he would now say thrusting) he realized that there was another movement, since the Pliocene strata gave evidence of a vertical movement following the period of folding. He now believes that there was a gentle, though not uniform, movement in the Alps at a late period, a movement which is still going on. The elevation began before erosion had done much work in the Alps, so that the topography so formed is not of striking appearance. As elevation continued, however, and the valleys were cut deeper into the Alpine overthrust mass, a very rugged topography resulted.

In conclusion, Professor Penck emphasized that this sequence of sinking, deposition, compression and folding with uplift is not shown by every orogenetic province, such as the Cordillera of the Colorado region.

During the discussion following the formal address the evidence of recent and continued movement in the Alps was further brought out by Professors Collet and Penck. There was at least one post-glacial volcanic eruption in the Alps, and even in the last few years earthquakes have been reported.

Professor Daly suggested as a cause of the uplift in the Alps the melting of the deep rocks with consequent increase in volume by as much as 10 per cent.

JOSEPH L. GILLSON,
Secretary, Boston Geological Society

SCIENTIFIC APPARATUS AND LABORATORY METHODS

A LOCATION FINDER FOR MICROSCOPES

EVERY one who has wasted precious time—and who has not?—in trying to find a particular portion of a microscope slide will be interested in a new device for accurately and readily locating on a slide any region of special interest.

The common practice of "ringing" such special regions (by India ink, wax and glass-cutting pencils) is crude at best, and under certain conditions difficult or even impossible (*e.g.*, with immersion oil on the slide, unremovable condensers). This device consists of (1) a lined chart (Figure 1) to be applied to the

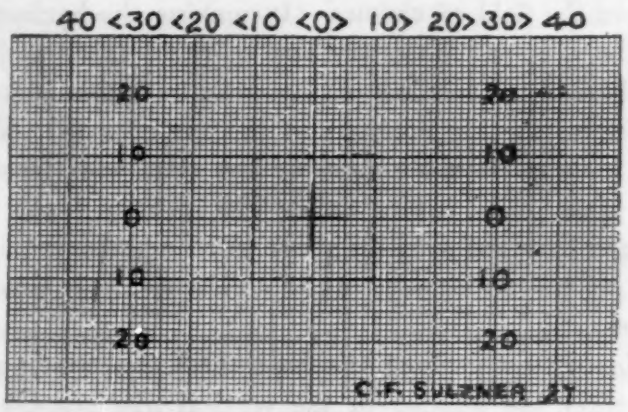

FIG. 1

ordinary stage, and (2) an inexpensive aluminum stage square to keep the microscope slide parallel to the stage chart lines and to control further the slide position, as described later.

When the stage of the microscope is thus marked or divided into millimeter spaces, as shown in Figure 1, locating any desired region on a microscope slide is greatly facilitated. To this end, the millimeter-spaced chart is first "centered" with a low-power objective, so that the intersection of the vertical zero and the horizontal zero lies in the optical axis. The chart having thus been centered, it is then held firmly in place, while corner after corner is carefully lifted, moistened on the under side with rubber cement, and pressed down on the stage. After verifying the optical-center-position of the chart, the glue or cement may be allowed to "set" and the detachable center removed, thus leaving a hole in the chart two centimeters square, which is larger than the original stage opening, and, therefore, prevents the chart from interfering with the passage of light or with the use of the condenser or immersion oil. (If the chart extends

beyond the stage, it may be quickly trimmed down by using a sharp scalpel or a safety razor blade.)

When a region of interest is noted, the worker makes sure that the slide is lying parallel with the stage chart lines, in order to determine accurately which of the horizontal and vertical lines are nearest to the slide. The parallel position of the slide may be assured by using the small aluminum try-square which forms part of this device. Since mechanical stages are by no means universally supplied on microscopes, even for advanced students and research workers, this simple, inexpensive aluminum square will be very helpful.

Having assured himself that the slide does lie parallel to the horizontal chart lines, and that the region of interest is still in the center of the field of vision, the worker reads the horizontal position of the near edge of the slide (*e.g.,* 19) by pulling back the aluminum square or the mechanical stage, thereby exposing clearly the near edge of the slide which is thus left lying in position with the region of interest still in the field of vision. (In making the horizontal readings, it will be easier and more accurate to take the horizontal reading of the near or lower edge of the slide, for the readings of the far edge of a slide will have to be made more or less slant-wise through the glass slide itself, unless the worker leans far enough forward over the stage to read the exact location of the under edge of the slide where it touches the chart.)

Having ascertained the horizontal line reading of the slide, the number of the vertical line nearest the left (or right) edge of the slide is next determined, giving us, let us say: left, <34, or right, 42>.

The exact location of the slide when the object of interest is in the field of vision may be recorded by using arrows as above, to indicate whether the left or right corner is the key or location corner, *e.g.,* 19. <34 or 19.42>); or by merely reversing the position of the higher vertical number as in the records 34.19 or 19.42. (It will, of course, be necessary to make sure that the slide is not reversed; the top edge of the slide is, however, usually clear from the writing on the label or markings on the slide itself.)

To locate again a region previously observed, it is only necessary to place the slide on any charted stage, with the key or record corner of the slide in the position called for by the record, in this case, the lower left corner at 19. <34 or the lower right corner at 19.42>.

This should bring the object into the field of vision with low powers, and very near it with high powers. With a mechanical stage, slight shiftings, front and back, and left and right, may be made, making sure that the slide is not moved far in any direction from its recorded location. With the aluminum square, it will be found best to determine the horizontal position (*e.g.,* 19) very exactly, and then move the slide to the vertical line recorded for it (left 34 or right 42). If the object is not then in the field of vision, shift the slide left and right slightly on the firm base afforded by the aluminum square; reset the square, if necessary, and again placing the slide with its lower edge against the aluminum square, shift it left or right as before described.

Note that the location readings obtained by such a location chart are universal in application—not only applicable to any microscope for which the worker has adjusted a location chart, but also universal in language, utilizing as it does only metric units (millimeters), arabic numbers and self-explanatory signs as the arrowheads.

This device, too, is easy to use. Since the optical axis is always zero, instead of some purely arbitrary number, no elaborate mathematics (subtractions, etc.) is demanded because of the arbitrary markings of the mechanical stage (*e.g.,* 82 in one microscope with fixed mechanical stage, purchased recently). Neither does this device involve adjusting the location records for variations for slide length. Note, too, that a universally applicable location record may be taken directly while the slide is actually in use by the worker, as it lies naturally on the stage, the only necessary precaution being that the slide must be parallel with the vertical and horizontal lines when any location reading is taken. No extra work is required: no "ringing," no removing of condensers or diaphragms, and no time-consuming verification of the location of the object of interest within the ring enclosure after the ring is made. All that is necessary is to read the intersecting lines at one corner of the slide and record them on the label or slide itself.

With this device one's own slides may be definitely charted, so to speak. Much that teachers now do for students may be done by the students themselves. Slides may be sent to others for comparison and consultation, with the assurance that we shall be talking about the same thing. And slides for sale or exchange may be given location readings which will multiply their value many times.

Samples of these water-proof paper stage charts, suitable for fastening to the ordinary microscope stage, with directions for application, may be secured by writing to the originator of this device, Mr. Charles Sulzner, in my care.

JEAN BROADHURST

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LABORATORY INCUBATOR FOR THE BIOLOGICAL STUDY OF CHICK EMBRYO

ONE of the very important problems in experimental embryology is the control of physical factors of incubation. Neither commercial nor laboratory incubators in use are adequately equipped or standardized. Consequently, the experimental data of different investigators[1] could hardly be compared and very often disagree. There is no uniformity whatsoever in comparative study of the initial growth, growth-cycles and some metabolic processes of chick embryo.

With a view to provide a perfect control of all physical factors of incubation (such as temperature, humidity, quality of air, ventilation and movement of eggs) in experimental work at the poultry husbandry department of Cornell University, a special electric laboratory incubator has been assembled and used successfully for almost two years. This incubator has facilities to serve: first, as a respiration apparatus, having both closed and open circuits; and secondly, as an ordinary incubator. Furthermore, it is so adapted that each variable physical factor can be independently and accurately controlled. The accuracy is shown by the average variations of incubation temperature and humidity, which, for instance, were less than 0.2° C. and 1.0 per cent. relative humidity. In addition to this, automatic alarms prevent accidents, and make it possible to do all the biological laboratory work without embarrassment or loss of time.

On the accompanying diagram there is shown by arrows the paths of air-flow through the incubator for each of the three systems: A, the closed respiration system ——→; B, the open respiration system - - - -→; and C, the open system without respiration apparatus · · · ·→. In the system A the absorbent (1: a, b, c, d and e) and the oxygen apparatus (2: a_1, b_1, c_1 and d_1) work simultaneously; in the system B the absorbent apparatus (1) works only; and in the system C the general condition is provided very close to that in commercial incubators, but more perfected. That is, outdoor fresh air, regardless of weather condition, is drawn by the blower (6) through the room-heating coil (5), the humidifier (11), the incubator-heating coil (17), and then, fully conditioned in respect to the temperature and humidity, through the egg chamber.

The egg chamber of the incubator, capacity 160 eggs, is air-tight, well insulated from the surrounding atmospheric conditions, and further, under the automatic control of the important physical factors of incubation: namely, heat, moisture, air, ventilation and movement of eggs. In use of the system C, for instance, these factors have been accomplished as follows.

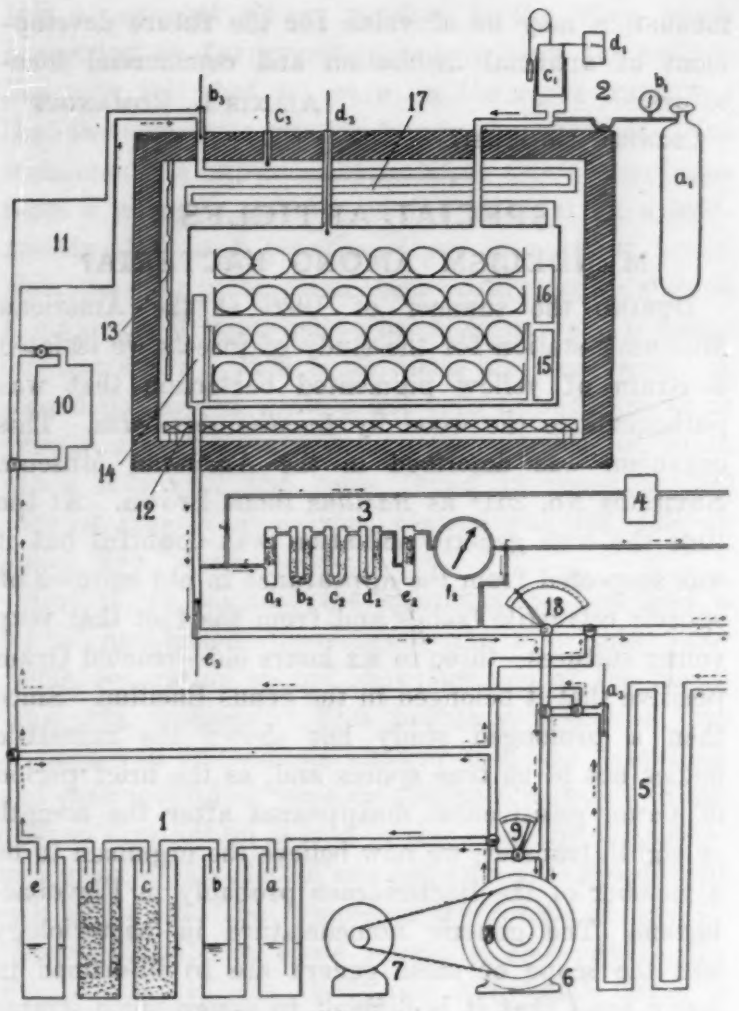

FIG. 1

The heat is supplied by the electric heater (12), regulated by the thermostat (13) and recorded by the thermograph (15) and the thermometers (a_3, b_3, c_3, d_3 and e_3). The moisture is supplied and regulated by the humidifier (11) and recorded by the hygrometer (16). The quality of air is regulated by means of changing from internal to external, or reverse ventilation at the valve (18), and determined in respect to the carbon dioxide content either by the residual system (3: a_2, b_2, c_2, d_2, e_2 and f_2) gravimetrically, or by the Haldane gas analysis apparatus (4) volumetrically, or by both. The ventilation is provided by the blower (6) driven by the electric motor (7), regulated by both the cone pulley (8) and by the by-pass valve (9), and recorded by the gas meter (10). The movement of eggs is controlled by the electric turning device (14).

With the above-described incubator it was possible to obtain a good, uniform control of the physical factors throughout the period of incubation; it is hoped that the attempt to study external factors of

[1] A. L. Romanoff, thesis (Ph.D.), Cornell University, June, 1928.

incubation may be of value for the future development of artificial incubation and commercial incubators.

ALEXIS L. ROMANOFF
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SPECIAL ARTICLES

MENDELISM AMONG BACTERIA?

DURING the summer of 1926 at the American Museum's station for the study of insects we isolated a strain of yellow pigmented bacterium that was pathogenic to the wood fly *Lucillia serricatta*. This organism was described in the American Museum Novitates No. 251[1] as *Bacillus lutzii* Brown. At the time the true generic affiliation was doubtful but it was suspected from the appearance in old cultures of spheric refractile bodies and from the fact that very young cultures—three to six hours old—reacted Gram positive that it belonged in the genus Bacillus. Since then a prolonged study has shown the refractile bodies not to be true spores and, as the brief period of Gram positiveness disappeared after the seventh or eighth transfer, we now believe the organism to be a member of the Bacteriacaea probably in Flavobacterium. The generic nomenclature in bacteriology and the scope of these genera are so ill-defined in many cases that it is difficult to assign some strains to any group. We at least do not feel qualified to originate any new generic names until the present ones are more fully understood.

Early in the work it became apparently difficult to keep the strains free of a yeast-like organism. Another difficulty appeared in the loss of color in one of the substrains. Both, while annoying at the time, have been found to be merely phases in the life history that, if we are correct in our inferences, may prove to be of more than passing interest.

As startling and as improbable as it may seem, we are of the opinion that we have been witnessing an exhibition of a case of Mendelism among asexual organisms. This statement may at outset seem contradictory to fundamentals, since Mendelism entails inheritance from two parents. However, a moment's reflection will reconcile it to some extent. It is a well-known and fundamental fact that great numbers of asexual organisms go through a process of conjugation during which portions of the nuclear material are exchanged. This is true in both the plant and animal kingdoms and now we propose that it is true in the intermediate bacterial kingdom.

Briefly, the life cycle of *F. lutzii* as exhibited under laboratory conditions and observed by us is as follows:

When the substrat becomes of such a nature as to interfere with the normal mode of existence as a rod-shaped organism, the rods undergo a series of morphological changes that terminate in a resistive stage. If the change in substrat is gradual, as might be caused by the natural accumulation of wastes in an old culture, many filamentous forms are developed and seem capable of existing long after the rods have died off. Upon transplanting these filaments the resultant culture is always one of pure rod forms. However, if the introduction to toxic material is sudden and if that toxic substance is of a cumulative type such as lead, a rapid change different in character occurs. A group of rods, eight in number we believe from lengthy observation, gather together and fuse into a mass. This mass is far more intensely stained by 1:10 aqueous basic fuchsin than the individual rods themselves are. This stage has been called by Löhnis[2] a symplasm.

While within this protective envelope the bacterial mass completely fuses and then gradually subdivides into two ill-defined parts and next into four spheric stain-resisting bodies. Each of these spheroids then passes through fission at right angles and tetrads are produced. These tetrads disintegrate into sixteen resistant "cocci." In time or upon being transplanted to a non-toxic nutrient medium each "coccus" again divides once, the increased volume due to this division causes the envelope to rupture and the "cocci" are released. If the substrat is suitable, they grow at once into normal rods and reassume the ability to take up aqueous basic fuchsin. These rods are of identical form, size, physiological and serological character with the initial rods.

If a single asexual "species" embraces strains varying in a character, such as color in our case, and if that character be Mendelian in its makeup, it is wholly conceivable that a stage of conjugation or, as the analogous bacterial stage may be called, symplasmism would bring this to light if carefully followed up. Apparently the difficulty heretofore obscuring its recognition has been the lack of a strikingly recognizable variable character. Our color character was ideal for this work as it was very definite and easily recognized.

Originally we set out to determine the cause of the loss of color in the substrain noted above. We at first believed it to be some obscure environmental cause and set out to eliminate as many as possible. We had found that by making daily transfers all strains kept their original color and that the only form present was rods. However, in the white strains

[1] F. M. Brown. American Museum Novitates No. 251. 1927.

[2] F. Löhnis and N. R. Smith. *Jour. Agric. Research*, 5: 676–702, 1916; *Jour. Agric. Research*, 23: 401–432, 1923.

whenever the culture was allowed to age a fortnight or more symplasms were formed and the outcome of transplanting was problematical so far as color was concerned; often both white and yellow colonies appeared on a single slant. Our theories relating metabolism and the color change were disproved by the fact that in these cases both colors developed under identical conditions in the same slant, so we were back where we started, looking for an answer.

Single-cell cultures of both yellow and white strains were now made and carried over a period of five months, being transferred every two weeks by means of single-cell isolations. This was carried on with some forty substrains. At the end of that time (eleven transfers having been made) substrains that showed no change of color from the first single-cell isolation were taken and considered to be pure strains of that color. Serological work proved them all to be identical. Inasmuch as our yellow strains had shown no variation in color since the split-off of the single white substrain over a year before, we turned our attention particularly to the white strains that were apparently pure and, covering the ground again, we proved to our own satisfaction that metabolism had nothing to do with the color change. At the same time we carried along a transfer from the original and parent culture that had been kept sealed with paraffin and on ice for fifteen months. No changes were observed with this strain.

We were about to give it up for a bad job when we mixed broth cultures of the two phases and plated it just to see what would happen. We got a pretty, variegated slant. The entire material was set aside and attention turned to other things. Two weeks or so passed and the time for the routine monthly transplants came around. Along with others, the tube of mixed strains was carried on. A few days later, on checking over the new transfers we were surprised to find that the mixed transfer was almost devoid of yellow areas. Interest was again stirred and, since there were a great many symplasms in the mixed strains tube, we entered upon a series of experiments to determine whether or not they had anything to do with it. Finally we evolved the following.

Since we had found that lead in a solid medium caused a rapid formation of the symplasm, we inoculated a lead-acetate nutrient agar slant with a freshly prepared mixed broth culture with a ratio of 1:1 million of cells of each strain. When many of the symplasms were observed to have ruptured and the resistant "cocci" were abundant in the smears we inoculated plain nutrient broth with material from the lead medium and after twenty-four hours plated thinly on nutrient agar. Numerous repetitions of this experiment always resulted in the white phase appearing in far greater numbers than the yellow. We now felt that we were on the right track and that the symplasm was the key to the situation. The technique was improved by isolating single symplasms from a saline suspension of the material on a lead-acetate slant and planting them in nutrient broth. Nutrient agar plates from these broth cultures showed a majority of white-phase colonies in every instance but one when a pure white phase was recovered. A second passage of white phase cells through the same process always resulted in a preponderance of white phase colonies. The ratio found in counting 500 colonies from a single such plating was 362:138, or about 8:3, white:yellow.

But if we consider the symplasm to represent a sexual generation, theoretically the first filial Mendelian generation should show but one of the variations, the dominant. This probably would be true if only two individuals entered into the symplasm and each individual were an alternate variant. Since neither supposition is true in this case, the superficial indication of Mendelism can not appear. Since eight cells enter into the symplasm the results in the F_1 generation will be those normally observed in the F_2—namely, in the thirty-two individuals from a single symplasm we would expect eight homozygous whites, sixteen heterozygous whites and eight yellows, provided the white cells are dominant as our work tends to indicate. But this is based on the supposition that equal numbers of white and yellow cells go to make a symplasm, and we can not control this, so a deviation from the expected ratio of 9:3 to about 8:3 simply means that in the symplasm used white character genes were slightly less in number than yellow. This might appear no matter how many colonies were counted unless in the mixture forming the symplasm there were exactly equal proportions of white and yellow cells. In the latter case the law of averages would balance things provided a sufficient number of colonies was counted to allow that law to function properly.

Our one stumbling-block in understanding all of this more clearly is this: How did an apparently pure recessive yellow strain throw the apparently dominant white strain? Frankly, we don't know.

Investigation by others along the same lines with color production and such characters as rough and smooth colonies, virulent and avirulent strains will be of great interest to us. Subcultures of our pure line strains are on deposit with the American Type Collection at the McCormick Institute in Chicago. We will welcome correspondence and further information as to heredity among asexual organisms.

We wish to acknowledge here the stimulation accorded us by Dr. Ralph R. Mellen, now of the Western Pennsylvania Hospital, Pittsburgh, Pa., through discussion, correspondence and his own admirable papers treating the subject of microbic heredity, and also by Dr. F. E. Lutz, of the American Museum of Natural History, for his interest in general.

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COD-LIVER OIL AND THE ANTIMONY TRICHLORIDE REACTION FOR VITAMIN A

During the months of January, February and March, 1928, I was in the Lofoten Islands, Norway, making a rather comprehensive survey of matters of importance in connection with cod livers and the oil produced from these livers. Many samples of oil were exported by me to the United States for animal assay and other lines of investigation. In addition to work of this character I was desirous of securing definite information as to the vitamin values of absolutely fresh Norwegian cod-liver oils produced by different methods from livers treated in a variety of ways. The use of biological methods of assay being out of the question, I equipped myself with a Lovibond tintometer and proceeded to assay my oil samples for vitamin A by the antimony trichloride reaction which was being widely used in England for the quantitative estimation of this vitamin in cod-liver oil.

In the course of my tests I made an observation which appeared to cast grave doubt upon the validity of the claim that the blue color produced in cod-liver oil by the addition of antimony trichloride is due to vitamin A. Since my return from Europe a very comprehensive and critical study has been made in our laboratories of the antimony trichloride reaction, with the result that we believe we have demonstrated most conclusively that this reaction does not afford a reliable means of determining the vitamin A content of cod-liver oil. We are now preparing full details for early publication. Our first Norwegian observation which cast doubt upon the validity of the claims made for the color reaction follows.

It is pretty generally accepted that cod-liver oil deteriorates when left open to light and air and that this deterioration is indicated, among other things, by a decrease in the vitamin A potency. In order to learn just how rapidly the vitamin A of fresh Norwegian cod-liver oil is destroyed when free access of light and air is permitted, I took two small tin pans of the same size and introduced the same volume of fresh oil into each and took a third sample for immediate colorimetric examination. I then placed one pan of oil in a clean, dry, dark closet and left the other pan of oil outdoors during the day uncovered, thus affording free access to rain, snow, sunlight and such particles of cinders and other dirt as might be blown into it. At night the pan was brought into the laboratory until morning. In the event of a driving rain or a particularly heavy fall of snow during the day, the pan was rescued and brought into the laboratory, but the oil was actually exposed to the elements for a total of seventy-nine hours during a period of two weeks.

It is doubtful if any sample of cod-liver oil was ever treated in a more shameful manner, during the time that its companion sample was supposed to be conserving its vitamin A in the seclusion of the dark closet.

At the end of two weeks these two oils were examined by me in the tintometer, using the antimony trichloride procedure. When I found that the cod-liver oil which had been standing open to air and light gave *a deeper blue color* than the original oil or the oil kept in the dark, I concluded that I had made some error in the technique and discarded all solutions and reagents and did not bother to finish the test. However, after making up a new oil solution with a different sample of chloroform and using a different bottle of antimony trichloride, I again found that the cod-liver oil which had been standing outdoors for seventy-nine hours possessed a higher value than either the original oil or the oil I had carefully protected in the dark closet. I then began to wonder if my eyesight had been injured through the monotony incident to looking at nothing but cod-fish, cod livers and cod-liver oil for a rather long interval. The idea that the antimony trichloride reaction was inaccurate did not at that moment suggest itself to me. However, when I examined the three samples of oil again on the following day and verified my previous findings, my confidence in the accuracy of the reaction was materially lessened.

Starting from the above initial observation, we believe that we have collected a mass of experimental evidence which very definitely indicates that the antimony trichloride reaction is not an accurate measure of the vitamin A potency of cod-liver oil. If this is true we must still consider the animal assay as the only accurate method by which cod-liver oil may be assayed for vitamin A.

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